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field and computer procedures for managed-stand yield tables

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Abstract

Sets of yield tables that show probable results of various management alternatives can be valuable tools for decisionmaking, especially when they can be made available quickly and at relatively low cost. Such tables can be obtained with data from temporary plots and the computer programs presented.

Key words: Stand yield tables, timber management, simulation, managed stands, Pinus ponderosa.

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FIELD AND COMPUTER PROCEDURES FOR MANAGED-STAND YIELD TABLES

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Introduction

Three publications have presented procedures for computation of yield tables for managed, even-aged stands. Two of these described field procedures to be used on temporary plots and analysis of the data obtained (Myers 1966, 1967); the third presented a computer program that calculated and printed yield tables, using functions described in the other papers (Myers and Godsey 1968).

Field procedures and computer programs described in this Paper are revisions and improvements of material in the publications cited above. Some modifications are in response to requests by users for applications other than those intended originally. Other changes are the result of increases in available data and greater insight obtained by applying the procedures to several tree species. They produce more realistic simulations of (1) stand growth, (2) response to intermediate cuttings, and (3) reproduction cutting by any of the even-aged systems. Improved procedures are used for computations such as periodic mortality and changes in average height and diameter with thinning.

The material presented includes descriptions of: (1) field measurements needed to produce yield tables for managed stands, (2) relationships to be obtained from the measurements, (3) a computer program written in FORTRAN IV that computes and prints yield tables, (4) an example of what the program can produce, and (5) a computer program useful in generating certain types of data. Tabular and functional relationships included apply to ponderosa pine (Pinus ponderosa Laws.) in the Black Hills of South Dakota and Wyoming. Instructions for adapting the procedures and programs to other species or forest regions are given.

Uses of Yield Tables

Yield tables for managed stands are essential guides for forest managers. They report probable wood yields that result from specified combinations of such factors as site quality, utilization standards, and frequency and intensity of thinning. They are, therefore, the basis for timber management planning. They also provide an important part of the information needed for determining the influence of timber treatments on all forest resources.

Yield tables for a species are useful regardless of the current level of management reached in forests of that species. Well-managed forests can benefit from refinements in operations that are guided by comparisons of actual conditions with a good standard. Where conversion to managed stands is underway, yield tables provide goals toward which conversion can be directed. Managers can better examine alternatives and reach decisions concerning goals through computerized simulation of forestry activities, a procedure that uses yield table computation in the set of mathematical operations (Myers 1968). Several factors influence the ways that yield tables should be produced and the types of data used to compute them. These factors include:

1. Yield tables for managed stands are needed even for regions and species where managed stands do not yet exist. The term "managed," as used here, means control of stand density throughout the life of the stand.
2. No single yield table can be adopted as standard for a species or region. Applied forest management requires the use of various practices that can and will differ from one forest to another, and must appear as variables in yield table computation.

3. A manager should not be restricted to only one yield table per working group, or series of stands managed under the same silvicultural system. He must have the opportunity to examine the probable results of his operations, to make necessary changes in the management of any of his resources, and to study the effects of these changes before money is spent on them.

The first item listed above appears to call for the use of temporary plots to obtain needed relationships. The next two sections of this Paper describe how data from temporary plots, permanent plots, or combinations of both can produce the relationships needed for yield table construction.

The second and third items above relate to a disadvantage of normal and empirical yield tables. One table can report probable yields for only one combination of stand characteristics and management objectives. This is not an effective basis for comparing alternatives and making decisions. Since a group of yield tables can show various combinations of characteristics and objectives, a means of producing many yield tables at low cost can be useful to a forest manager. Computer programs for doing this are described below and listed in the appendices. Once the needed relationships between stand variables have been established, a manager can examine the probable outcomes of many possible variations in management. There is no need to delay decisions or to speculate on what may happen if a condition or procedure changes. Large numbers of tables, each based on a specified set of alternatives, can be computed and printed at a cost of a few cents each.

General Description of Methods

Nine items of information, described in the next section, are needed to compute yield tables for even-aged, managed stands. The first item, the residual stand desired after each cutting, is based on all pertinent information available and may apply to several species and regions. Data for the second item, appearance of unthinned young stands, are obtained from a few measurements made on temporary plots. The other seven items are based on data from temporary and/or permanent "growth-prediction plots" that are measured in detail. Analyses of plot data described below depend on the availability of tree volume equations and site index curves applicable to the species and locality (Bruce and Schumacher 1950, Chapman and Meyer 1949). Procedures for estimation of site index from soil and topography may be used where stand density indicates that the conventional height-age relationship will give inaccurate results (Myers and Van Deusen 1960).

Growth-prediction plots are temporary or permanent plots placed in carefully selected, even-aged stands. They should sample numerous combinations of site index and stand density, including extreme values of possible interest. The sample should contain a full representation of ages or average diameters, at least to the longest rotations for which yield tables may be prepared. Plots must also conform to the usual requirements as to uniformity of site quality, range of tree sizes, and stand density across a plot. They must be large enough to provide an adequate representation of the distribution of trees by diameter classes. The stands must not have been partially cut or otherwise disturbed during the period for which growth is measured. They must not be diseased or infested by insects to the extent that growth is affected, unless this is to be a variable in yield table construction.

It may sometimes be desirable or necessary to combine data from temporary and permanent plots. Or, functions can be derived from temporary plot data with permanent plots used as benchmarks to verify accuracy of the predictions. The discussion that follows assumes that temporary plots will provide most or all the data needed.

Most forest regions contain stands of various ages and with densities in the range of possible interest. Such stands provide a readily available store of growth information. Data from temporary plots in these stands are entirely adequate for yield table construction and, except for measures of periodic mortality, do not differ in plot values or variability from data from equivalent permanent plots (Décourt 1965, Myers 1966, Vuokila 1965).

Measurements made on each growth-prediction plot must include the following:

1. Plot area.
2. Heights and ages of trees suitable for site index determination. Alternatively, soil and topographic measurements useful in estimating site index are obtained.
3. D.b.h. of each tree, to 0.1 inch.
4. Total height of each tree to 1.0 foot, or of each of a sample if there are many trees on the plot. If height is sampled, sufficient measurements must be taken to construct

a height-diameter curve for the plot. A good sample of the heights of dominant and codominant trees is also needed so the average height of such trees can be computed.

5. Crown class of each tree.
6. Total ages of a sample of dominant and codominant trees. This measurement may be omitted if even-aged status is not in doubt or if equivalent ages are obtained for site index determination.
7. Radial wood growth during the period of interest, to 0.05 inch, from increment borings at breast height along the best estimates of average radius. The period selected will be the unit prediction period of the computer program that computes and prints the yield tables.
8. D.b.h. outside bark of each tree that died during the period selected for item 7. If necessary, diameter inside bark is measured and then converted to diameter outside bark.
9. Several cut or leave codes for each tree, based on trial markings of each plot to simulate several intensities of thinning. This information is used to determine increases in diameter and height due to thinning, as described in items 4 and 6 of the section headed Information Needed.

Other field measurements will be needed if local experience indicates that additional independent variables are significant in the regression equations described below.

Plot and tree data computed initially from the field measurements are as follows:

1. Site index.
2. Past d.b.h. of each tree from present d.b.h., radial wood growth, and periodic bark growth (Myers and Van Deusen 1958).
3. Height of each tree for which the actual height was not measured. A height-diameter curve or function for each plot provides any missing heights.

Measured and computed items that describe the present stand are used to compute the following values for each plot. Amounts per acre are computed, where applicable.

1. Number of live trees.
2. Basal area.
3. Average d.b.h., computed as the tree of average basal area.
4. Average height of dominant and codominant trees.
5. Average age of main-stand trees.
6. Cubic feet, from ground to tip, of all trees. This and the following item are obtained from tree volume equations.
7. Volumes in any other units of interest.

Past diameters of live trees, diameters of the tallied dead trees, and present stand age provide the following items that describe the stand at the beginning of the prediction period.

1. Number of trees.
2. Basal area.
3. Average d.b.h., computed as the tree of average basal area.
4. Average age of main-stand trees, from present age and the length of the prediction period.

Once the plot measurements have been obtained and summarized, each item described in the next section is computed as one or more relationships to be placed in the computer program. These functions are the species-specific elements of the programs, and are replaced if the program is to apply to other species or utilization standards.

Information Needed

This section contains instructions for obtaining the nine items that appear as one or more FORTRAN statements each in PONYLD, the computer program that produces yield tables (appendix 1). Most of the items are obtained by regression analysis of plot values described in the previous section. Data for the first two items described come from other sources, including appropriate references in the literature. Additional information of field and computation procedures can be found in standard mensuration texts (Bruce and Schumacher 1950, Chapman and Meyer 1949).

Tabulations include only enough entries to explain the nature of the information needed. They do not indicate sample sizes or desirable ranges of data.

Program statements relating to one or more of the nine items must be changed to adapt PONYLD to other species or conditions. Suggested program modifications are given in the section headed Modification of PONYLD.

1. Stocking After Cutting.

Stand density to be left after each cutting is expressed as a relationship between basal area and average stand diameter (table 1). Basal area is an easily measured variable that is highly correlated with growth in size and

Table 1.--Basal areas after intermediate cutting in relation to average stand diameter growing stock level 80

Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre
	Sq. ft.		Sq. ft.		Sq. ft.		Sq. ft.
2.0	12.1	4.0	35.2	6.0	56.6	8.0	72.5
2.1	13.2	4.1	36.4	6.1	57.6	8.1	73.1
2.2	14.4	4.2	37.6	6.2	58.5	8.2	73.7
2.3	15.5	4.3	38.7	6.3	59.4	8.3	74.3
2.4	16.7	4.4	39.9	6.4	60.3	8.4	74.8
2.5	17.9	4.5	41.0	6.5	61.2	8.5	75.3
2.6	19.0	4.6	42.2	6.6	62.1	8.6	75.8
2.7	20.2	4.7	43.4	6.7	62.9	8.7	76.3
2.8	21.3	4.8	44.5	6.8	63.8	8.8	76.7
2.9	22.5	4.9	45.7	6.9	64.6	8.9	77.1
3.0	23.7	5.0	46.8	7.0	65.4	9.0	77.5
3.1	24.8	5.1	47.8	7.1	66.2	9.1	77.9
3.2	26.0	5.2	48.8	7.2	67.0	9.2	78.2
3.3	27.1	5.3	49.8	7.3	67.7	9.3	78.5
3.4	28.3	5.4	50.8	7.4	68.5	9.4	78.8
3.5	29.5	5.5	51.8	7.5	69.2	9.5	79.1
3.6	30.6	5.6	52.8	7.6	69.9	9.6	79.3
3.7	31.8	5.7	53.8	7.7	70.6	9.7	79.5
3.8	32.9	5.8	54.7	7.8	71.2	9.8	79.7
3.9	34.1	5.9	55.7	7.9	71.9	9.9	79.8
						10.0+	80.0

volume. The relationships fit well into computer algorithms and provide thinning guides for application of treatments to actual stands.

Results of thinning studies and data from temporary plots are used to construct a graph of desired basal area over average stand diameter for local average site quality. "Best" stand density for each average diameter sampled can be based on such criteria as production in cubic feet and probable length of saw log rotations. Selected basal areas are plotted over corresponding stand diameters, and a curve is drawn through the points. If the relationship appears reasonable, it is then expressed as a mathematical function.

In table 1, basal area increases with diameter until 10.0 inches diameter is reached, and remains constant thereafter. The designation "growing stock level 80" indicates that basal area is 80.0 square feet when diameter is 10.0 inches or larger, regardless of what basal area may be at lower average diameters.

Desired stand density will vary with the objectives of management, and a family of basal area-diameter relationships is needed (fig. 1.). The original single curve or function of basal area on diameter is treated as a guide curve from which other curves can be produced. Basal areas for any growing stock level can be computed by multiplying the guiding values for level 80 in table 1 by the ratio level/80. For example, basal areas for level 100 are each 100/80 times the corresponding basal areas of table 1. The level designations are the variables THIN, DLEV, and DSTY in PONYLD (appendix 1).

The curves of figure 1 define growing stock goals for many possible management objectives, including the possibility of holding stand density above or below levels that give the best saw log or roundwood production. Any desired form of the guide curve may be used if the appropriate statements of PONCUT are modified properly.

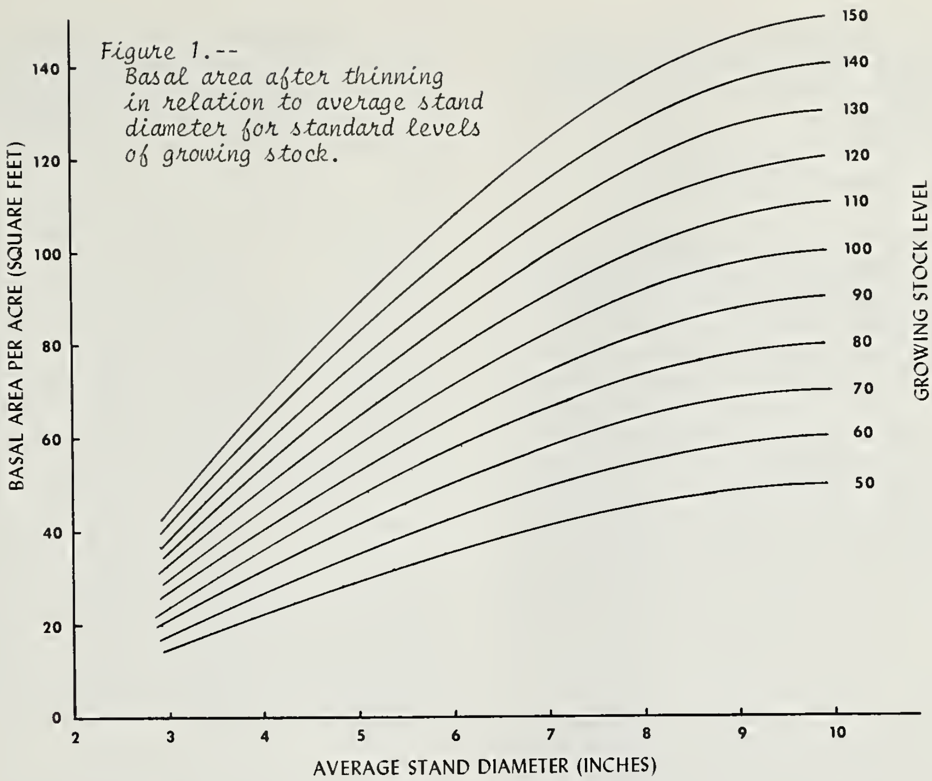

Figure 1.--Basal area after thinning in relation to average stand diameter for standard levels of growing stock.

Relationships shown in table 1 appear as functions for level 80 in program PONYLD. Basal areas computed from these functions are multiplied by terms that include the desired growing stock level (THIN or DLEV) to obtain values for other growing stock levels. Variables for which FORTRAN statements are needed and their use, are:

a. DBHP - to find a d.b.h. less than 10.0 inches when basal area is known. Three equations for DBHP are used to simplify representation of the nonlinear relationship between d.b.h. and basal area.
b. BREAK and BUST - to compute values of basal area that are the upper limits of applicability of the first two equations for DBHP.
c. SQFT - to find basal area when d.b.h. is known. Two equations represent the nonlinear relationship for d.b.h. less than 10.0 inches.

2. Description of Unthinned, Young Stands.

Values in the first line of each yield table describe stand conditions just prior to initial thinning. They are entered directly from data cards or are computed from the data. Users of PONYLD must, therefore, be able to describe the stands that do or should exist at time of initial thinning. In a yield table for managed stands, the stand density and related average diameter given in the first line result when stand regeneration and subsequent growth and mortality progress as planned.

Numerous unthinned, young stands can be examined to determine: (1) site index, (2) average stand d.b.h., (3) number of trees per acre, and (4) stand age. In selecting plots, preference should be given to those stands that represent possible regeneration goals for various objectives of management. For each site index class, average d.b.h. is determined for various combinations of stand age and number of trees per acre. Any influence of the overstory must be included where shelterwood or seed tree systems are used.

3. Diameter Increase From Growth.

Regression analysis of data obtained on the growth prediction plots described in the previous section provides an equation for prediction of future average stand d.b.h. In terms of the plot data described above, present average d.b.h. of ponderosa pine is estimated from past d.b.h., site index, and past basal area per acre. Additional independent variables may be useful for other species or localities. The prediction period is determined by the number of rings

measured on increment cores. The equation for ponderosa pine and for a 10-year prediction period appears in PONYLD as the FORTRAN statement for DBHO.

4. Diameter Increase From Thinning.

Change in average stand diameter caused by intermediate cuttings can be estimated from data obtained during repeated trial marking of the plots described previously. Numerous intensities of cutting are simulated on each plot, and each tree is coded as cut or leave at each trial. Since the dimensions of each plot tree are known, volumes and other values can be determined for each potential residual stand. Values useful in computation of prediction equations for diameter change and other items include: average d.b.h., basal area per acre, percentage of trees retained, average height, volumes per acre of entire stems in cubic feet (total cubic feet), and volumes in other units of interest.

In PONYLD, diameter after thinning is estimated from diameter before thinning and the percentage of trees to be retained. Regression analysis of data from the simulated thinnings provide functions for DBHE and PDBHE. These two variables represent the same item, diameter after thinning. DBHE is computed directly if the estimated percentage of trees to be retained is at least 50 percent. With fewer trees retained, the relationship is highly nonlinear, so PDBHE is computed and its antilogarithm becomes DBHE.

Because of the numerous possible combinations of initial stand density, stocking level, and initial stand diameter, trial marking of sample plots may not provide all the information needed. A supplementary procedure is described in the section headed Description of Program PONCHK and in appendix 3.

5. Height of Dominants and Codominants.

Average heights of dominant and codominant trees are computed from data obtained on growth-prediction plots where height growth apparently has never been reduced by high stand density. Regression analysis of the data provides functions for estimating height for various combinations of site index and stand age (table 2). These functions appear as statements for HTSO in PONYLD. Two functions are used to cover the range of possible ages. With the procedure used to account for changes in height from thinning, average d.b.h. cannot be used instead of site index and age to predict height.

Table 2.--Average height (feet) of dominant and codominant trees at various ages, Black Hills ponderosa pine (as computed by statements for HTSO)

Main stand age (Years)	Site index class			
	40	50	60	70
20	8	10	13	16
30	12	16	21	25
40	17	22	28	34
50	21	28	36	43
60	26	33	41	49
70	30	39	47	56
80	34	43	52	62
90	37	47	57	66
100	40	50	60	71
110	43	53	64	74
120	45	56	67	77
130	47	58	69	80
140	48	60	71	82
150	50	62	73	85
160	51	63	75	87

Table 2 is similar to table 1 of Technical Bulletin 630 (Meyer 1938). This suggests that heights from good site index curves or tables may supplement or substitute for local data, until adequate sampling can be completed. If site index data are used, they must be based on the same crown classes as the equations for stand volume in cubic feet, described below.

6. Height Increase From Thinning.

Changes in the average height of dominant and codominant trees due to partial cutting are estimated the same way as changes in average diameter. Results of repeated trial markings provide the data needed to compute the prediction function. In PONYLD, the variable ADDHT is the computed amount of change. The percentage of trees retained is the only independent variable used. At each cutting, the current value of ADDHT is added to height before thinning, HTSO, to obtain height after thinning, HTST. It is also added to a cumulative sum of changes, HTCUM, so computed heights before thinning will show the effects of past treatment as well as of age. Computed values of ADDHT are small because average heights and their changes refer to dominant and codominant trees, only.

As with diameter, it may be difficult to sample many combinations of stocking level, initial stand density, and initial average height. The supplementary procedure described in the section Description of Program PONCHK may be useful in such cases.

7. Noncatastrophic Mortality.

Reduction in numbers of trees may be important in unthinned stands, but minor and erratic in thinned stands. Such is the case with ponderosa pine in the Black Hills. A prediction equation for mortality could not be computed for thinned stands with an average d.b.h. of 10.0 inches or larger. Small reductions are made in PONYLD for thinned and unthinned stands of smaller diameter.

The prediction equation in PONYLD for percentage of mortality expressed as a decimal (DIED) contains average stand d.b.h. and basal area per acre, both at the beginning of the period, as independent variables. Data to compute such equations can be obtained from two sources:

a. Permanent plots that have been measured at least as frequently as the prediction period to be used.
b. Growth-prediction and other temporary plots that have not been partially cut for at least a number of years equal to the prediction period. It must be possible to estimate the number of years since death for each tree that died during the prediction period.

8. Stand Volume Equation.

Plot tallies of tree diameters and heights are converted to volumes per acre and other stand measures, as already described. Data from growth prediction plots, results of simulated thinnings, and other available stand tallies are used. Volumes are computed in total cubic feet and in other units of interest with appropriate tree volume equations (Myers 1964). Only total cubic feet will be used to compute stand volume equations. Total cubic volume per acre from ground line to tip of all trees more than 4.5 feet tall is the only volume computed directly by PONYLD. It is, therefore, the only unit for which a stand volume equation will be needed.

Two forms of the stand volume equation have proven useful. They are:

$$V = a + b_1 BH + b_2 D \qquad (1)$$

$$V = (a + b_1 D^2 H + b_2 B) \times N \qquad (2)$$

where

V = gross total cubic volume per acre.
B = basal area per acre in square feet.
H = average height of dominant and codominant trees.
D = average stand d.b.h. in inches.
N = number of trees per acre.

Stand volume equations appear as statements to compute CUFT. Two statements are used because the relationship is not linear over the ranges of BH or D^2H that can appear in the yield tables.

Stand volume equations must apply over a wide range of stand densities and average diameters. Procedures described in the section Description of Program PONCHK may be useful in providing the variety of conditions needed for regression analysis or test of the functions.

9. Volume Conversion Factors.

Program PONYLD computes volumes in units other than total cubic feet of bole wood from cubic volumes per acre and appropriate conversion factors. Plot data that produce stand volume equations must, therefore, also provide conversion factors. Data from growth prediction plots, trial thinnings, and other sources are used to compute plot volumes in various units, as described previously. Merchantable cubic feet, board feet, square feet of veneer, weight per acre, or other units may be computed. Then, the quantity of each unit per total cubic foot is determined separately for each plot. Selection of appropriate units includes choice of minimum merchantable top diameters and diameters at breast height. The second column, below, shows some of the ratios used to obtain equations for FCTR. The third column shows ratios used for PROD.

Average stand d.b.h. (Inches)	Merchantable cubic feet ÷ total cubic feet	Board feet ÷ total cubic feet
5.1	0.355	--
6.0	.552	--
6.9	.725	--
8.3	.860	0.99
9.1	.901	1.55
10.3	.931	2.38
19.0	.962	5.33
23.4	.969	5.88

Ratios need not be computed for the smallest average stand diameters because the factors vary greatly in such stands. This has no important effect on yield table construction. Merchantable material will not be a part of thinnings until stand diameter is large enough for conversion factors to be reliable.

Regression analysis provides functions to compute conversion factors from other stand variables. FCTR can be estimated from average stand d.b.h. Estimates for PROD for ponderosa pine are improved if basal area per acre is also included in the equation. More than one equation for FCTR and PROD appear in PONYLD so the relationships can be expressed by simple linear functions over a wide range of d.b.h.

As with stand volume equations, conversion factors must apply over a wide range of stand conditions. The description of program PONCHK, below, presents a solution to this problem.

Description of Program PONYLD

Program PONYLD consists of a main program and two subroutine subprograms written in standard FORTRAN IV. The main program reads the data cards, performs most computations, and writes the yield tables. Subroutine PONCUT determines the new average stand diameter after cutting to the specified growing stock level. Subroutine PONVOL computes volumes in total cubic feet per acre, and factors to convert these volumes to other units. Operations performed by each routine are indicated by comment statements in the source program (appendix 1).

Initial operations are the reading of the five data cards described in the tabulation of the order and contents of the data deck. The first two cards enter values that will not change during a computer run. One variable, NTSTS, controls the number of sets of yield tables to be produced, one for each group of cards of types 3, 4, and 5. Other variables determine which volumes from intermediate cuts will be included in the total yields printed at the bottom of each table, and the basis of the growing stock levels. Three data cards are read for each test. They enter the number of tables to be produced in a set, initial stand conditions, and controls on the operations to be performed. Entry of a negative or zero value for any variable on card types 1 to 4 or for REGN(1) on card type 5 will cause the printing of an error message and termination of the job.

Order and Contents of the Data Deck for Program PONYLD

Card type	Number of cards	Variable name	Columns	Format	Description of variable
1	1	NTSTS	1-4	I4	Number of tests per batch. The number of sets of yield tables to be produced.
		GIDE	5-8	F4.0	Base level of set of growing stock levels, as the 80. in table 1 and figure 1.
2	1	COMCU	1-8	F8.3	Minimum cut in merchantable cubic feet to be included in total yields. Must be at least 1.0.
		COMBF	9-16	F8.3	Minimum cut in board feet to be included in total yields. Must be at least 1.0.
3	1 per test	JCYCL	1-4	I4	Interval between intermediate cuts. A multiple of RINT.

Card type	Number of cards	Variable name	Columns	Format	Description of variable
		MIX	5-8	I4	Number of stocking levels or values of DLEV to be examined in one test.
4	1 per test	AGEO	1-8	F8.3	Initial age to be shown in a yield table. Stand age when first thinning occurs.
		DBHO	9-16	F8.3	Average stand d.b.h. just prior to initial thinning at stand age AGEO.
		DENO	17-24	F8.3	Number of trees per acre just prior to initial thinning at stand age AGEO.
		DSTY	25-32	F8.3	Lowest growing stock level for intermediate cuts after initial thinning. Level will increase by 10 as many times as specified by MIX on card type 3.
		RINT	33-40	F8.3	Number of years for which a growth equation makes one projection. Value is 10.0 for statements in appendix 1.
		SITE	41-48	F8.3	Site index for the species.
		THIN	49-56	F8.3	Growing stock level for initial thinning at age AGEO. May equal DLEV.
5	1 per test	REGN(1)	1-8	F8.3	Stand age at which first regeneration cut will occur. Must never be zero or blank, as REGN(1) is rotation length for clearcutting.
		VLLV(1)	9-16	F8.3	Percentage of previous DLEV to be left at age REGN(1). Will be zero with clearcutting.
		INVL(1)	17-24	F8.3	New interval between cuts in effect after age REGN(1). Will be zero with clearcutting.

REGN(2)	25-32	F8.3	Stand age at which second regeneration cut, if any, will occur. Removal of seed trees or second cut of shelterwood.
VLLV(2)	33-40	F8.3	Percentage of previous DLEV (including effect of VLLV(1)) to be left at age REGN(2). May be zero.
INVL(2)	41-48	F8.3	New interval between cuts in effect after age REGN(2). May be zero.
REGN(3)	49-56	F8.3	Stand age at which third regeneration cut, if any, will occur. Final cut of 3-cut shelterwood.

All operations from statement 30 to statement 160 are performed for each table. The tables of a set differ by the growing stock level to be left after the second or later thinnings (DLEV). The first table of each set is computed with the subsequent level entered as DSTY on card type 4. Each following table will be computed with second and later thinnings cut to a level 10 higher than that of the previous table. Operations performed for each table are:

1. Computation of height and volumes just prior to initial thinning.
2. Partial cutting to the growing stock level specified by THIN for initial thinning or by DLEV for subsequent cutting. Cutting will not be simulated if the stand is already below the basal area specified by THIN or DLEV.
3. Computation of post-cutting volumes and other values.
4. Printing of table headings the first time through the loop and, each time through the loop, printing of values appropriate for the stand age.
5. Projection of diameter, height, and stand density for one or more periods until the next intermediate cut is scheduled. Stand volumes and other values are computed and printed at ages when no cutting is scheduled.
6. Repetition of steps 2 to 5 until stand age at time of initial regeneration cutting is reached.
7. Redefinition of the growing stock to be left after cutting and the interval between regeneration cuttings. Operations are guided by entries on card type 5. Clearcutting calls for only one entry, stand age at time of removal or REGN(1). Seed tree cutting requires entry of values for all items on card type 5 to and including REGN(2) which is the age when seed trees are to be removed. The interval between regeneration cutting, REGN(1), and removal of seed trees is INVL(1). Shelterwood cuttings are controlled similarly except that up to three cuts are possible. Stand age at final cut will be REGN(2) for two-cut shelterwood and REGN(3) for three-cut shelterwood.
8. Regeneration cuts are accomplished by repetition of steps 2 to 7, until the age of final cut is reached.
9. Printing of column totals for volumes removed. Volumes less than COMCU and COMBF on card type 2 will not be included in the totals so that commercial yields may be compared, if desired. Actual column totals may be obtained by entering values of 1.0 for COMCU and COMBF on card type 2.

Subroutine PONCUT computes average stand diameter after cutting from diameter before cutting and the percentage of trees retained. The percentage of trees retained is needed as an independent variable, but is itself an unknown. Successive percentages of trees are therefore tested until d.b.h. after thinning, number of trees retained, and residual basal area agree with the diameter and basal area combination called for by THIN or DLEV.

These combinations, shown in table 1, appear in PONCUT as statements for DBHP in the second loop and as REST in the first loop.

Two loops provide for the increasing and constant segments of each growing stock level line (fig. 1). Limiting d.b.h. for selection of loops is 10.0 inches minus the average change expected over a range of cuttings in stands just under 10.0 inches d.b.h.

Subroutine PONVOL computes total cubic feet per acre and factors to convert this to other units. Conversions to merchantable cubic feet and to board feet are shown in the listing in appendix 1. Utilization standards for these units are given in the comment statements of PONVOL. Conversions to other units or utilization standards may supplement or replace those already in PONVOL. Additional units might be square feet of veneer or wood weight in pounds (Myers 1960).

Program PONYLD should run with little or no modification on any computer that accepts FORTRAN IV, has a minimum of 32K words of storage, and has two input/output devices (unit 5 for program and data deck input and unit 6 for printed output). Changes to adapt the program to other tree species or utilization standards and for additional computations are described in the section headed Modification of PONYLD.

An Application of PONYLD

The problem described below demonstrates the computations made by PONYLD and the printed results obtained. It illustrates some of the questions that may be asked and the information that will be provided. The example also serves as a test problem for use in adapting the source program to locally available computing facilities.

A forest manager wishes to determine the intensity of thinning that will maximize volume production in board feet in stands of site index 70. Length of the cutting cycle has not been standardized, but will be 20 years for this test. He also wants to compare yields from two-cut and three-cut shelterwood, both with the final removal cut scheduled for stand age 130 years and considering the current crop, only. Alternatives calling for more than one precommercial thinning are unacceptable. Minimum commercial volumes per acre are 320 cubic feet to a 4-inch top and 1,500 board feet. The manager expects that his procedure for regeneration cuts will result in a new stand that contains 950 trees per acre by age 30, with an average diameter of 4.8 inches.

The data deck consists of the 32 cards shown in figure 2. The first card calls for

10	80						
320		1500					
20	5						
30		48	950	80	10	70	80
110		50	20	130			
20	5						
30		48	950	80	10	70	90
110		50	20	130			
20	5						
30		48	950	80	10	70	100
110		50	20	130			
20	5						
30		48	950	80	10	70	110
110		50	20	130			
20	5						
30		48	950	80	10	70	120
110		50	20	130			
20	5						
30		48	950	80	10	70	80
90		666	20	110	50	20	130
20	5						
30		48	950	80	10	70	90
90		666	20	110	50	20	130
20	5						
30		48	950	80	10	70	100
90		666	20	110	50	20	130
20	5						
30		48	950	80	10	70	110
90		666	20	110	50	20	130
20	5						
30		48	950	80	10	70	120
90		666	20	110	50	20	130

Figure 2.--Data deck for test problem.

10 tests, so there will be 10 sets of one each of card types 3, 4, and 5. The second card enters minimum merchantable volume limits. The third card, a type 3 card that is repeated nine more times, enters the 20-year cutting cycle and information that five subsequent thinning levels are to be examined in each test. With 10 tests of five thinning levels each, the computer will produce 50 yield tables. For brevity, only a few of them are reproduced in appendix 2.

The fourth card of the data deck, a type 4 card that follows the type 3 card, differs from other type 4 cards only in the thinning level that controls initial thinnings. For each of the two shelterwood cuttings, levels 80, 90, 100, 110, and 120 will each be imposed at age 30.

The fifth card is the type 5 card for two-cut shelterwood. A removal cut that retains half the basal area specified for the subsequent thinning level is scheduled for age 110. The final cut will be made at stand age 130. The type 5 card is the same for the first five tests to be performed. Card number 20 of the data deck is also a type 5 card. This card and the other four type 5 cards specify three-cut shelterwood with cuts at ages 90, 110, and 130. The first removal cut leaves two-thirds of the basal area of the subsequent thinning level. The second removal cut leaves half the basal area left after the first removal cut.

Yield tables produced by PONYLD, a few of which are reproduced in appendix 2, can

assist in decisionmaking in many ways. Money yields and rates earned can be computed by applying thinning costs and stumpage values to the volumes given in the tables. Stand ages at culmination of mean annual increment, and rates earned assist in the selection of rotations.

For the situation described above, yields and numbers of precommercial thinnings are of greatest immediate interest. These items are summarized in tables 3 and 4 for the 50 yield tables produced. Combinations of low initial and low subsequent growing stock levels or of high initial and intermediate subsequent levels produce the greatest volumes with one precommercial thinning. Additional comparisons should be made to include such factors as probable thinning costs, cubic yields from thinnings not commercial for board feet, and the average size of tree produced. As expected, the current crop produces more board feet in 130 years if cut by two-cut shelterwood than if by three-cut shelterwood. The latter treatment may, however, get the next crop off to an earlier start.

The manager may now wish to vary the interval between cuts and other variables subject to his control. The production of many more yield tables is entirely practical. The 50 tables already examined required only 17.9 seconds of central processor time on a CDC 6400 computer.

Table 3.--Yields in board feet, including commercial thinnings, of the 50 combinations of initial and subsequent thinning levels.

Initial thinning level	Subsequent thinning level				
	80	90	100	110	120
	M bd. ft.				
	TWO-CUT SHELTERWOOD				
80	28.0	29.3	29.5	31.3	31.8
90	27.7	27.7	29.5	31.4	34.0
100	25.9	27.7	29.1	31.3	33.8
110	26.0	27.4	29.1	31.3	34.1
120	25.7	27.3	29.3	30.9	33.2
	THREE-CUT SHELTERWOOD				
80	25.7	27.0	26.5	29.0	29.2
90	25.3	25.3	26.5	28.9	31.8
100	23.6	25.2	26.2	29.0	31.5
110	23.4	25.2	26.2	29.0	31.8
120	23.2	25.0	25.9	28.5	31.0

Table 4.--Number of precommercial thinnings if each of the 50 combinations of initial and subsequent thinning levels is executed as specified by the data deck (both types of cutting gave the same results)

Initial thinning level	Subsequent thinning level				
	80	90	100	110	120
80	1	2	2	2	[1]1
90	1	1	2	2	2
100	1	1	2	2	2
110	1	1	1	2	2
120	1	1	1	2	2

[1]One scheduled thinning could not be made.

Modification of PONYLD

PONYLD can be modified in many ways to answer questions of the "what would happen if I did this" type. Several possible modifications are listed here.

To Change Species:

PONYLD can be converted to apply to a different species than the ponderosa pine used in the example. This change requires new statements to compute HTSO, ADDHT, DBHO, and DENO in the main program. Replacement of statements for CUFT, FCTR, and PROD are needed in PONVOL and for DBHE and PDBHE in PONCUT. Another definition of growing stock than that shown in table 1 and figure 1 requires new statements for BREAK, BUST, DBHP, and SQFT. A new base value (GIDE) can be entered on card type 1 if a level other than 80 is the base of the new growing stock levels. Ways of obtaining function for these variables are given in the section headed Information Needed.

To Include Losses:

Modifications can be made to include the effects of insects or diseases on tree growth and stand density. How this may be done for dwarf mistletoe is explained elsewhere (Myers et al. 1971).

To Add Other Measures:

Quantities other than potential wood yields can be computed. For example, stand measurements used to compute volumes can also be used to compute the amount of slash that would be produced by cutting the quantities specified in the tables.

To Study Actual Stands:

Analysis of actual, thinned stands has been a frequently used modification of the original version of PONYLD. In this case, stand conditions after initial cutting are known, and information on possible response to this and future treatments is desired. Alternatively, the unmarked component of the stand is known and the purpose of analysis is to determine if treatment is justified. Modification may be accomplished with the following changes in the main program:

1. Read AGEO, DBHO, and DENO as usual, to describe the actual stand just prior to thinning.
2. Add a READ statement after the READ statement for card type 4 to enter actual values of DBHT, DENT, HTST, and BAST. These describe the stand immediately after initial thinning.
3. Change the DIMENSION statement from VAR(10) to VAR(14).
4. Follow the READ card of step 2 with five statements:
```
VAR(11) = DBHT
VAR(12) = DENT
VAR(13) = HTST
VAR(14) = BAST
JDENT   = DENT
```
5. Replace the statement labeled 55 with two statements:
```
55  IF(K .EQ. 1) GO TO 56
    CALL PONCUT
```
This will bypass the initial thinning.
6. Place three statements between GO TO 60 and the statement labeled 58:
```
56  ADDHT  = HTST - HTSO
    HTCUM  = HTCUM + ADDHT
    GO TO 59
```
7. Add a label to the statement for STAND, three statements after label 58:
```
59  STAND = DENT
```
8. Place four statements just before the CONTINUE statement labeled 160:
```
DBHT  = VAR(11)
DENT  = VAR(12)
HTST  = VAR(13)
BAST  = VAR(14)
JDENT = VAR(12)
```

To Add Variability:

A modification of PONYLD primarily of interest as a research tool is the addition of random elements to each prediction. Several stands with exactly the same basal area, site index, etc. do not all produce the same periodic growth or have the same volume conversion factors. A prediction equation will, however, indicate the same average response for all the stands. Response in the presence of variability can be studied by adding statements to compute the random elements, running the program several times, and then analyzing the results statistically.

Modification of PONYLD to add variability to computations of DBHO illustrates how such changes can be made. The following statements are added to the program immediately after the statements that compute DBHO and round it to 0.1 inch.

```
98  IDIV = (17.0 * GNTR + 3.0) / 1024.0
    NGNTR = GNTR
    GNTR = (17 * NGNTR + 3) - 1024
       * IDIV
    IF(GNTR .GT. 1000.0) GO TO 98
    IF(GNTR .LT. 0.0) GO TO 98
    A1 = GNTR / 100.00
    A2 = A1 * A1
    RES = 0.9565 * A1 - 0.0523 * A2 - 0.0063
       * A1 * A2 + 0.00084 * A2 * A2
       - 3.3009
    IRES = RES
    IF(RES .LT. 0.0) IRES = RES - 0.5
    IF(RES .GT. 0.0) IRES = RES + 0.5
    ADJ = IRES
    DBHO = DBHO + ADJ * 0.1
```

The statement for IDIV is a congruential pseudo-random number generator (Greenberger 1961). A value of the variable GNTR is read into memory at the beginning of the program. It is the "seed" of the generator and may be any number from 0 to 1023, inclusive. This variable, or the entire statement, is varied in successive runs of PONYLD to give the results an opportunity to differ.

The statement for RES is an empirical distribution function obtained by fitting a polynomial to the normally distributed residuals of the DBHO equation (Evans et al. 1967).

The computation is made in three steps: (1) generation of a pseudo-random number, (2) use of this number as an independent variable to compute the value of a normally distributed residual (range: -0.3 to +0.3 inch for DBHO), and (3) addition of the residual algebraically to the computed value of DBHO.

To Include Overstory:

An addition may be needed for tables with shelterwood or seed tree cuts if the regeneration period is long enough for the next crop to affect growth of the overstory. In this case, PONYLD should be run twice. The first run provides basal areas at appropriate times early in the life of a stand. Changes are then made for the second run, which will be the production run. BAST of the DBHO equation becomes total basal area of overstory and understory for growth projections made late in the life of the overstory after the new crop trees are large enough to influence overstory growth.

Description of Program PONCHK

Most functions described in the section headed Information Needed are computed with rather large amounts of plot data. The functions must apply to many combinations of several stand variables and to the wide range of stand density possible in thinned and unthinned stands. It is possible, however, to calculate additional data for use in regression analyses of several of these functions from lesser amounts of actual field data. The derived functions must, of course, be checked for accuracy. If acceptable, they may be used in production runs of PONYLD. If not good enough for this, they may be used, until additional field data are obtained, for preliminary modeling and adapting PONYLD to local equipment and species.

Program PONCHK, listed in appendix 3, uses plot stand tables to calculate volumes, volume conversion factors, and changes in diameter and height due to thinning. Thinnings that leave about 10, 17, 20, 25, 33, 50, 67, and 75 percent of the trees are simulated. Printed output of PONCHK provides both dependent and independent variables needed to obtain functions for CUFT, FCTR, PROD, DBHE, and ADDHT. Also shown are the volumes removed by each level of thinning, including the merchantable cubic volume in trees below saw log size.

Data cards needed to run PONCHK are shown in the accompanying tabulation. The last card of the data deck is a type 1 card

Order and Contents of the Data Deck for Program PONCHK

Card type	Number of cards	Variable name	Columns	Format	Description of variable
1	1 per plot	NPLT	1-3	I3	Plot number
		NTIM	4-5	I2	Diameters from measured d.b.h. (2) or from increment borings (1)
		NWHN	6-7	I2	Field plot is unthinned (1) or thinned (2)
		AREA	8-12	F5.3	Plot area
		AGE	13-16	F4.0	Average age of main stand
2	1 per tree	DBH	1-3	F3.1	Tree diameter to 0.1 inch
		HT	4-6	F3.0	Tree height to the nearest foot
		CC	7-9	F3.0	Tree crown class: dominant (1), codominant (2), intermediate (3), or overtopped (4)

with 888 punched in the NPLT field. Type 2 cards of each plot are arranged in order of increasing diameter. The last type 2 card of each plot has 99.9 (punched 999) in the DBH field.

The sequence of operations is shown by the COMMENT statements of the program. Summations and computations of averages follow usual procedures. Simulation of thinnings by PONCHK is accomplished for a plot as follows:

1. A modulo for the pseudo-random number generator, which is appropriate for the number of trees per acre, is computed.
2. As many pseudo-random numbers are generated as there are trees on one acre, using the generator provided and the "seed" value of the statement labeled 1 (Greenberger 1961).
3. Trees are rearranged at random.
4. Groups of randomly arranged trees are created with the size of each group determined by the percentage of trees to be retained.
5. Appropriate trees from each group are tallied. For example, with PRET = 25.0, the largest tree of each group of four is tallied. For PRET = 75.0, the smallest tree of each group of four is ignored and the other three are tallied.
6. Volumes and other values are computed for each percentage of trees retained.

In tests to date, functions computed from data from simulated thinnings agree with results of field operations. For example, equations for DBHE derived from simulated data usually predict post-thinning diameters that vary 0.1 inch or less from actual values.

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APPENDIX 1

Listing of Program PONYLD

```
      PRDGRAM PDNYLD
     1(INPUT,DUTPUT,TAPE5=INPUT,TAPE6=DUTPUT)
C
C TD CDMPUTE ANO PRINT YIELD TABLES FOR MANAGED EVEN-AGED STANDS.
C
C OEFINITIDNS DF VARIABLES.
C
C      ADDHT = INCREASE DR DECREASE IN AVERAGE STAND HEIGHT BY THINNING.
C      AGED = INITIAL AGE IN YIELD TABLE.
C      BASC = BASAL AREA CUT PER ACRE.
C      BASD = BASAL AREA PER ACRE BEFDRE THINNING.
C      BAST = BASAL AREA PER ACRE AFTER THINNING.
C      BDFC = BDARD FEET CUT PER ACRE.
C      BDFO = BDARD FEET PER ACRE BEFDRE THINNING.
C      BDFT = BDARD FEET PER ACRE AFTER THINNING.
C      CFMC = MERCHANTABLE CU. FT. CUT PER ACRE.
C      CFMD = MERCH. CU. FT. PER ACRE BEFORE THINNING.
C      CFMT = MERCH. CU. FT. PER ACRE AFTER THINNING.
C      CDMBF = MINIMUM CDMMERCIAL CUT, BDARD FEET.
C      CDMCU = MINIMUM CDMMERCIAL CUT, CU. FT.
C      DBHD = AVERAGE STAND D.B.H. BEFORE THINNING.
C      OBHT = AVERAGE STAND D.B.H. AFTER THINNING.
C      DENC = TREES CUT PER ACRE.
C      OEND = TREES PER ACRE BEFORE THINNING.
C      DENT = TREES PER ACRE AFTER THINNING.
C      DIED = PERCENTAGE, AS A DECIMAL, DF TREES THAT DIE DURING PERIDO
C             RINT.
C      OLEV = GRDWING STOCK LEVEL FDR INTERMEDIATE CUTS AFTER FIRST.
C      DSTY = LDWEST VALUE DF DLEV USED IN A TEST.
C      GIDE = BASE FOR GROWING STDCK LEVELS, BD.D IN EXAMPLE SHOWN.
C      HTSD = TREE HEIGHT BEFDRE THINNING.
C      HTST = TREE HEIGHT AFTER THINNING.
C      INVL(I) = NEW CUTTING CYCLE AFTER REGENERATIDN CUT I.
C      JCYCL = INTERVAL BETWEEN INTERMEDIATE CUTS.
C      JSBD = SUM DF BOARD FEET FRDM ALL CUTS WITH YIELD DF CDMBF DR
C             LARGER.
C      JSMC = SUM DF MERCH. CU. FT. FRDM ALL CUTS WITH YIELD DF COMCU DR
C             LARGER.
C      JSTF = SUM DF TDTAL CU. FT. FRDM ALL CUTS.
C      MIX = NUMBER DF STDCKING LEVELS EXAMINED PER TEST.
C      NTSTS = NUMBER DF TESTS PER BATCH.
C      PRET = PERCENTAGE DF TREES RETAINEO AFTER THINNING.
C      REGN(I) = STAND AGE WHEN REGENERATION CUT I OCCURS.
C      RINT = NUMBER OF YEARS FDR WHICH PRDJECTIDN IS MADE.
C      ROTA = FINAL AGE IN YIELD TABLE.
C      SITE = SITE INDEX.
C      THIN = GRDWING STDCK LEVEL FDR INITIAL THINNING.
C      TOTC = TOTAL CUBIC FEET CUT PER ACRE.
C      TDTO = TDTAL CUBIC FEET PER ACRE BEFDRE THINNING.
C      TDTT = TDTAL CUBIC FEET PER ACRE AFTER THINNING.
C      VLLV(I) = PERCENT DF PREVIDUS DLEV TD BE LEFT AT REGN(I), ENTERED
C             AS A DECIMAL.
C
      COMMDN BA,BAST,CUFT,DBHD,DBHT,DEND,FCTR,HITE,GIDE,PRET,PROD,REST,S
     ITAND,VOM
      DIMENSIDN INVL(3),REGN(3),VAR(10),VLLV(3)
C
      OO I J=I,ID
    1 VAR(J) = O.D
C
C READ NUMBER DF TESTS PER BATCH AND BASE DF GRDWING STDCK LEVELS FRDM
C CARD TYPE DNE.
C
      READ (5,5) NTSTS,GIDE
    5 FDRMAT (I4,F4.0)
      IF(NTSTS .LE. D) GO TD 17D
      IF(GIDE .LE. D.D) GD TD I70
C
C READ MINIMUM CDMMERCIAL CUTS FDR CDMPUTATIDN DF CDLUMN TDTALS FRDM
C CARD TYPE TWO.
C
      READ (5,ID) CDMCU,CDMBF
   ID FDRMAT (IOFB.3)
      VAR(B) = CDMCU
      VAR(9) = COMBF
C
C EXECUTE PRDGRAM DNCE FOR EACH SET OF INITIAL VALUES DF INTEREST.
C
      DD I6D I=I,NTSTS
      JTEM = D
C
C READ CUTTING INTERVAL AND LEVELS PER TEST FRDM CARD TYPE THREE.
C
      READ (5,I5) JCYCL,MIX
   I5 FDRMAT (2I4)
      IF(JCYCL .LE. D .DR. MIX .LE. O) GD TO I7D
      JTEM = JCYCL
C
C READ INITIAL STAND VALUES FRDM CARD TYPE FDUR.
C
      READ (5,10) AGED,DBHD,DEND,DSTY,RINT,SITE,THIN
      VAR(1) = AGED
      VAR(2) = OBHD
      VAR(3) = DEND
      VAR(4) = DSTY
      VAR(5) = RINT
      VAR(6) = SITE
      VAR(7) = THIN
C
C READ SILVICULTURAL CDNTRDLS FRDM CARD TYPE FIVE.
C
      READ (5,ID)REGN(I),VLLV(I),INVL(I),REGN(2),VLLV(2),INVL(2),REGN(3)
      VAR(ID) = REGN(1)
      DD 20 L=I,ID
      IF(VAR(L) .LE. D.D) GO TD I7D
   2D CDNTINUE


      DLEV = D.D
      OD 25 NA=I,3
      L = 4 - NA
      IF(REGN(L) .EQ. O.D) GD TO 25
      RDTA = REGN(L)
      GD TD 30
   25 CDNTINUE
C
C PROVIDE FDR SEVERAL GRDWING STDCK LEVELS PER TEST.
C
   30 DD 160 M=I,MIX
      ADDHT = 0.0
      BDFD = 0.0
      BDFT = 0.0
      CFMD = 0.0
      CFMT = 0.0
      HTCUM = 0.0
      JSBD = 0
      JSMC = 0
      JSTF = 0
      TEM = M
      OLEV = (DSTY + (TEM * I0.0)) - I0.0
      BASD = OEND * 0.0054542 * DBHD * DBHO
C
C DBTAIN AVERAGE HEIGHT AND VDLUMES PER ACRE.
C
C-----STATEMENTS FDR HTSD AND IF STATEMENT ARE SPECIES-SPECIF(C.
C
      IF(AGEO .GT. 55.0) GD TD 35
      HTSD = D.0144I * AGED * SITE - D.12I62 * AGED - 1.5D953
      GD TD 40
   35 HTSD = 0.59947 - 6I.5DI9 / AGEO + D.BD522 * ALOGID(SITE) + 2D.5252
     IB * ALDGID(SITE) / AGED
      HTSD = I0.0 ** HTSD
   40 HITE = HTSD
      BA = BASO
      STANO = DEND
      VDM = DBHD
      CALL PDNVDL
      TDTD = CUFT
      BDFD = CUFT * PRDD
      CFMD = CUFT * FCTR
      REST = THIN
C
C ENTER LDDP FDR REMAINING CDMPUTATIDNS AND PRINTDUT.
C
      DD 13D K=1,IDD
C
C CHANGE STANDARDS IF A REGENERATION CUT IS DUE.
C
   43 IF(AGED .GE. RDTA) GD TD 60
      IF(AGEO .LT. REGN(I)) GD TD 55
      IF(AGED .NE. REGN(I)) GD TO 45
      DLEV = DLEV * VLLV(I)
      REST = DLEV
      JCYCL = INVL(I)
      GD TD 55
   45 IF(AGED .NE. REGN(2)) GD TD 50
      DLEV = DLEV * VLLV(2)
      REST = DLEV
      JCYCL = INVL(2)
      GD TD 55
   5D IF(AGED .NE. REGN(3)) GD TD 55
      DLEV = DLEV * VLLV(3)
      REST = DLEV
      JCYCL = INVL(3)
C
C INCREASE D.B.H. BY THINNING AND CDMPUTE PDST-THINNING VALUES.
C
   55 CALL PDNCUT
      JDENT = (BAST / (D.DD54542 * OBHT * DBHT)) + D.5
      DENT = JDENT
      BAST = D.DD54542 * DBHT * DBHT * DENT
      IF(BAST .LT. BASO) GD TD 5B
      BAST = BASD
      HTST = HTSD
      OENT = DEND
      JDENT = DEND + 0.5
      DBHT = DBHD
      TDTT = TDTD
      BDFT = BDFD
      CFMT = CFMD
      GD TD 60
C
C-----STATEMENT FDR ADDHT IS SPECIES-SPECIFIC.
C
   5B ADDHT = 7.64B33 - 3.B22B6 * ALDGIO(PRET)
      HTCUM = HTCUM + ADDHT
      HTST = HTSD + ADDHT
      STANO = DENT
      VOM = DBHT
      HITE = HTST
      BA = BAST
      CALL PDNVOL
      TDTT = CUFT
      BOFT = CUFT * PRDD
      CFMT = CUFT * FCTR
C
C CHANGE MDDE AND ROUND DFF FDR PRINTING.
C
   60 JAGED = AGED
      JSITE = SITE
      JDEND = DEND + D.5
      JHTSD = HTSD + 0.5
      JTDTD = (TDTD * D.1) + D.5
      JTDTO = JTDTD * I0
      JBASD = BASD + D.5
      JCFMD = (CFMD * 0.1) + D.5
      JCFMD = JCFMD * 1D
      JBDFD = (BOFD * 0.DI) + D.5
      JBDFD = JBDFD * IDO
      JHTST = HTST + D.5
      JTDTT = (TDTT * 0.I) + D.5
      JTDTT = JTDTT * 1D
      JCFMT = (CFMT * D.I) + D.5
      JCFMT = JCFMT * 10
      IF(JCFMT .GT. JCFMD) JCFMD = JCFMT
      JBDFT = (BDFT * 0.DI) + D.5
      JBDFT = JBOFT * 10D
      IF(JHDFT .GT. JBDFD) JBOFO = JBDFT
      JBAST = BAST + D.5
      JDENC = JDEND - JDENT
```

```
      JBASC = JBASO - JBAST
      JTOTC = JTOTO - JTOTT
      JCFHC = JCFMO - JCFMT
      IF(JCFHC .LE. 0) JCFHC = D
      JBDFC = JBDFO - JBDFT
      IF(JBDFC .LE. 0) JBDFC = D
C
C SUH PERIDDIC CUTS FOR LAST LINE OF YIELD TABLE.
C
      IF(AGEO .GE. RDTA) GO TD 70
      JSTF = JSTF + JTOTC
      CFHC = JCFHC
      IF(CFMC .LT. COMCU) GD TD 65
      JSHC = JSHC + JCFHC
   65 BOFC = JBOFC
      IF(BOFC .LT. COMBF) GD TD 7D
      JSBD = JSBD + JBDFC
C
C WRITE HEADINGS FOR YIELD TABLE.
C
   7D IF(K .GE. 2) GD TO 92
C
C-----CHANGE TABLE HEADING FDR DTHER SPECIES.
C
      WRITE (6,80) JSITE,JCYCL
   8D FDRMAT (1H1,///,37X,62HYIELDS PER ACRE DF MANAGED, EVEN-AGED STAND
     1S DF PDNDEROSA PINE/IHD,48X,11HSITE INDEX ,I3,IH,,I4,19H-YEAR CUTT
     2ING CYCLE)
      WRITE (6,82) THIN,DLEV
   82 FDRMAT (1HD,41X,26HTHINNING LEVELS= INITIAL -,F6.D,14H, SUBSEDUENT
     I -,F6.D)
      WRITE (6,84)
   84 FDRMAT (1HD,25X,38HENTIRE STAND BEFDRE AND AFTER THINNING,28X,26HP
     1ERIDDIC INTERMEDIATE CUTS)
      WRITE (6,86)
   86 FDRMAT (IHD,9X,5HSTAND,10X,5HBASAL,3X,7HAVERAGE,2X,7HAVERAGE,3X,5H
     1TDTAL,3X,9HMERCHANT-,3X,9HSAWTIMBER,9X,5HBASAL,4X,5HTDTAL,3X,9HMER
     2CHANT-,3X,9HSAWTIMBER)
      WRITE (6,88)
   88 FDRMAT (1H ,1DX,3HAGE,4X,5HTREES,3X,4HAREA,4X,6HD.B.H.,3X,6HHEIGHT
     1,2X,6HVOLUHE,2X,11HABLE VDLUHE,4X,6HVDLUME,3X,5HTREES,3X,4HAREA,3X
     2,6HVDLUME,2X,11HABLE VDLUME,4X,6HVOLUHE)
      WRITE (6,90)
   90 FORHAT (IH ,8X,7H(YEARS),3X,3HND.,3X,6HSQ.FT.,4X,3HIN.,6X,3HFT.,4X
     1,6HCU.FT.,5X,6HCU.FT.,6X,6HBD.FT.,4X,3HND.,3X,6HSQ.FT.,2X,6HCU.FT.
     2,5X,6HCU.FT.,6X,6HBD.FT.)
C
C WRITE TABLE ENTRIES DF DIAMETER, VDLUMES, ETC.
C
   92 WRITE (6,94) JAGED,JDEND,JBASD,DBHD,JHTSD,JTDTD,JCFHD,JBDFD
   94 FDRHAT (1HD,9X,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X,I6)
      IF(AGEO .GE. RDTA) GD TD I35
      WRITE (6,96) JAGED,JDENT,JBAST,DBHT,JHTST,JTDTT,JCFHT,JBDFT,JDENC,
     1JBASC,JTDTC,JCFHC,JBOFC
   96 FDRMAT (IH ,9X,I4,4X,I5,2X,I4,5X,F5.I,5X,I3,4X,I5,6X,I5,6X,I6,4X,I
     I5,3X,I3,5X,I4,6X,I4,8X,I5)
C
C COHPUTE VALUES FDR EACH PERIOD. THIN AS SPECIFIED.
C
      IRINT = RINT
      IK = JCYCL / IRINT
      DD 12D L=1,IK
      AGEO = AGED + RINT
      IF(AGED .GT. RDTA) GD TD 135
C
C COHPUTE NEW D.B.H. BEFDRE THINNING AND RDUND OFF TO D.I INCH.
C
C-----STATEHENT FDR DBHD IS SPECIES-SPECIFIC.
C
      OBHD = 1.DD97 * DBHT + D.DD96 * SITE-(1.5766*ALDG10(BAST))+3.3D21
      IOBHD = DBHD * 10.0 + 0.5
      DBHD = IDBHO
      DBHD = OBHD * D.I
C
C-----STATEMENT FOR DIED IS SPECIES-SPECIFIC. CHANGE 1D.D IN IF
C-----STATEHENT IF OIED STATEMENT APPLIES TO LARGER TREES.
C
      IF(DBHT .GE. 1D.D) GO TD 1DD
      DIED = 0.00247 + D.D0124 * DBHT + D.DDD28 * DBHT * DBHT + D.00DDD5
     121 * BAST * BAST - D.DDDD905 * DBHT * BAST
      IF(DIED .LT. D.D) DIED = D.D
      DEND = DENT * (1.D - OIED)
      MNK = DEND + D.5
      DEND = MNK
      GD TD 1D5
  100 DEND = DENT
  I05 BASO = DEND * (D.DD54542 * DBHD * DBHD)
C
C DBTAIN AVERAGE HEIGHT ANO VDLUMES PER ACRE.
C
C-----STATEHENTS FDR HTSD AND IF STATEHENT ARE SPECIES-SPECIFIC.
C
      IF(AGED .GT. 55.0) GO TD 11D
      HTSD = D.D1441 * AGED * SITE - D.12162 * AGED - I.5D953
      GD TD 115
  11D HTSD = 0.59947 - 6I.5D19 / AGED + D.8D522 * ALDG1D(SITE) + 20.5252
     18 * ALDG1D(SITE) / AGED
      HTSD = 1D.0 ** HTSD
  115 HTSD = HTSD + HTCUH
      STANO = DEND
      VDM = DBHD
      HITE = HTSD
      BA = BASD
      CALL PDNVDL
      TDTD = CUFT
      BDFD = CUFT * PRDD
      CFMD = CUFT * FCTR
C
C TEST IF REGENERATIDN CUT IS DUE.
C
      DD 118 KU=1,3
      IF(AGED .EQ. REGN(KU)) GO TD 43
  118 CDNTINUE
C
C CHANGE MODE ANO RDUND DFF FDR PRINTING.
C
      IF(L .ED. IK) GD TD 125
      KDEND = DEND + 0.5
      KAGED = AGED
      KHTSD = HTSD + D.5
      KBASD = BASD + 0.5
      KTDTD = (TDTD * D.1) + D.5
      KTOTO = KTDTD * 1D
      KCFHD = (CFMD * D.1) + D.5
      KCFMD = KCFMD * 1D
      KBDFD = (BDFD * D.0I) + D.5
      KBOFO = KBOFD * IOD
```

```
C
C WRITE VALUES FOR THE PERIDO IF THINNING IS NDT OUE.
C
      WRITE (6,94) KAGEO,KOEND,KBASD,OBHO,KHTSD,KTOTO,KCFMD,KBOFO
      DBHT = DBHD
      BAST = BASD
      DENT = DEND
  I20 CDNTINUE
  125 REST = DLEV
  13D CDNTINUE
C
C ADD FINAL CUTS TD TDTAL YIELDS ANO WRITE TDTAL YIELDS.
C
  135 JSTF = JSTF + JTDTD
      CFMD = JCFMD
      IF(CFHD .LT. CDHCU) GO TD 14D
      JSHC = JSHC + JCFHD
  140 BDFD = JBDFD
      IF(BDFD .LT. COMBF) GD TD 145
      JSBD = JSBD + JBDFD
  145 WRITE (6,15D) JSTF,JSMC,JSBD
  15D FDRMAT (1HD,/,67X,I2HTDTAL YIELDS,2DX,I4,6X,I4,8X,I5)
      WRITE (6,155) CDMCU,CDMBF
  155 FDRMAT (IHO,//,11X,44HHINIHUM CUTS FOR INCLUSIDN IN TDTAL YIELDS--
     I,F6.0,15H CUBIC FEET AND,F7.D,11H BDARD FEET)
      WRITE (6,156)
  156 FDRMAT (1HD,1DX,66HMERCH. CU. FT. - TREES 6.D INCHES D.B.H. AND LA
     1RGER TD 4-INCH TDP.)
      WRITE (6,157)
  157 FDRMAT (IHO,IDX,6OHBD. FT. - TREES 1D.D INCHES D.B.H. AND LARGER T
     1D 8-INCH TDP.)
C
C PREPARE FDR NEXT TABLE OF THE TEST.
C
      AGED = VAR(I)
      OBHD = VAR(2)
      DEND = VAR(3)
      JCYCL = JTEM
  160 CONTINUE
      GD TU 2D0
  17D WRITE (6,175)
  175 FORMAT (1H1,///,1DX,66HEXECUTIDN STDPPED BECAUSE DF NEGATIVE DR ZE
     1RD ITEH DN A OATA CARD.)
  2DO CALL EXIT
      END

      SUBRDUTINE PDNCUT
C
C TD ESTIMATE INCREASE IN AVERAGE D.B.H. OUE TD THINNING.
C
      CDMMON BA,BAST,CUFT,DBHD,DBHT,DEND,FCTR,HITE,GIDE,PRET,PROO,REST,S
     1TAND,VDM
C
      IF(DBHD .LT. 9.4) GD TO 3D
C
C COMPUTE D.B.H. IF DBHO IS LARGE ENDUGH FOR BASAL AREA TD REMAIN CDNSTANT.
C
      PRET = 1CD.D
      DO 21 KJ=1,1DD
C
C-----STATEMENTS FDR OBHE AND PDBHE ARE SPECIES-SPECIFIC.
C
      IF(PRET .LT. 5D.D) GD TD 5
      DBHE = D.73365 + 1.D2008 * DBHD - 0.D11D7 * (PRET - 5D.D) - 0.0D01
     14 * (PRET - 5D.D) * (PRET - 5D.D)
      GO TD 11
    5 PDBHE = D.49401 + D.7189D * ALDGIO(DBHD) - D.2253D * ALDG1D(PRET)
     1 + 0.I2616 * ALOG1D(DBHO) * ALOG1O(PRET)
      OBHE = 10.0 ** PDBHE
   I1 IDBHE = DBHE  * I0.0 + D.5
      DBHE = IDBHE
      DBHE = DBHE * 0.1
      DENE = DEND * PRET * 0.01
      NDENE = DENE + D.5
      DENE = NDENE
      BASE = 0.0054542 * OBHE * DBHE * DENE
      NBASE = BASE * 1D.D + D.5
      BASE = NBASE
      BASE = BASE * D.1
      THPY = D.D054542 * DBHE * DBHE
      TEM = BASE - REST
      IF(TEM .LE. THPY) GD TD 7D
      IF(TEM .LT. 4.0) GO TD 2D
      PRET = PRET - 1.D
      GD TD 21
   2D PRET = PRET - 0.3
   21 CONTINUE
      GD TO 70
C
C COMPUTE D.B.H. IF BASAL AREA INCREASES WITH 0.B.H.
C
   3D PRET = 40.0
      IF(DBHD .GT. 7.D) PRET = 7D.D
      DD 65 J=I,IDD
C
C-----STATEHENTS FOR DBHE AND PDBHE ARE SPECIES-SPECIFIC.
C
      IF(PRET .GE. 5D.0) GD TD 4D
      PDBHE = D.494D1 + D.71890 * ALDG1D(DBHO) - 0.2253D * ALOG1D(PRET)

     1 + 0.12616 * ALDG10(DBHD) * ALDGID(PRET)
      DBHE = 10.0 ** PDBHE
      GD TO 45
   40 DBHE = D.73365 + 1.D2DD8 * OBHD - D.D11D7 * (PRET - 5D.D) - D.DOD1
     14 * (PRET - 50.D) * (PRET - 50.D)
   45 IDBHE = DBHE * 10.D + D.5
      DBHE = IDBHE
      DBHE = DBHE * D.1
      DENE = DEND * (PRET * D.D1)
      NDENE = DENE + 0.5
      DENE = NDENE
      BASE = D.0054542 * DBHE * DBHE * OENE
      NBASE = BASE * 1D.D + O.5
      DASE = NBASE
      BASE = BASE * D.1
C
C-----CHANGE STATEMENTS FOR BREAK, BUST AND FIRST 3 STATEMENTS FDR DBHP
C-----IF DTHER GROWING STDCK LEVEL BASE THAN TABLE 1 IS USED.
C
```

```
      BREAK = 49.9 * REST / GIOE
      IF(BASE .GT. BREAK) GO TO 50
      OBHP = (GIOE / REST) * (0.08682 * BASE) + 0.94636
      GO TO 52
   50 BUST = 66.2 * (REST / GIDE)
      IF(BASE .GT. BUST) GO TO 51
      OBHP = (GIOE / REST) * (0.10938 * BASE) - 0.17858
      GO TO 52
   5I TMPY = BASE * (GIOE / REST)
      TEM = TMPY * TMPY
      08HP = 19.04740 * TMPY - 0.26673 * TEM + 0.0012539 * TEM * TMPY
     I - 448.76833
      IF(TMPY .GT. GIOE) OBHP = 08HO + 0.8
   52 IOBHP = OBHP * 10.0 + 0.5
      OBHP = IOBHP
      08HP = OBHP * 0.1
      IF(08HP - 08HE) 60,70,61
   60 PRET = PRET * 1.02
      GO TO 65
   61 PRET = PRET * 0.98
   65 CONTINUE
   70 OBHT = OBHE
C
C COMPUTE POST-THINNING BASAL AREA.
C
C-----CHANGE TWO IF STATEMENTS ANO STATEMENTS FOR SQFT IF OIFFERENT
C-----GROWING STOCK LEVEL BASE IS USEO.
C
      IF(OBHT .GT. 5.0) GO TO 75
      SQFT = 1I.58495 * 08HT - 1I.09724
      GO TO 76
   75 IF(O8HT .GE. 10.0) GO TO 77
      TEM = OBHT * OBHT
      SQFT = 7.76226 * OBHT +0.85289 * TEM -0.07952 * TEM * OBHT-3.45624
   76 BAST = (REST / GIOE) * SQFT
      GO TO 80
   77 BAST = REST
   80 RETURN
      ENO



      SUBROUTINE PONVOL
C
C
C TO COMPUTE VOLUMES PER ACRE IN VARIOUS UNITS.
C
      COMMON BA,BAST,CUFT,OBHO,OBHT,OENO,FCTR,HITE,GIOE,PRET,PROO,REST,S
     1TANO,VOM
C
      FCTR = 0.0
      PROO = 0.0
C
C COMPUTE TOTAL CUBIC FEET PER ACRE.
C
      O2H = VOM * VOM * HITE


C
C-----STATEMENTS FOR CUFT ANO IF STATEMENT ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6000.0) GO TO 5
      CUFT = (0.00225 * 02H - 0.00074 * BA + 0.03711) * STANO
      GO TO IO
    5 CUFT = (0.00247 * 02H + 0.00I30 * BA - I.40286) * STANO
   10 IF(VOM .LT. 5.0) GO TO 40


C
C OBTAIN CONVERSION FACTORS FOR MERCH. CU. FT. - VOLUMES TO 4.0-INCH TOP
C IN TREES 6.0 INCHES O.B.H. ANO LARGER.
C
C-----THREE STATEMENTS FOR FCTR ANO FIRST TWO IF STATEMENTS ARE SPECIES-
C-----SPECIFIC.


C
      IF(VOM .GT. 6.7) GO TO 15
      FCTR = 0.26612 * VOM - I.12689
      GO TO 25
   15 IF(VOM .GT. 10.4) GO TO 20
      FCTR = 3.46993 - 0.12017 * VOM - 13.41984 / VOM
      GO TO 25
   20 FCTR = 0.99666 - 0.66932 / VOM
   25 IF(VOM .LT. 8.0) GO TO 40

C
C OBTAIN CONVERSION FACTORS FOR 80. FT. - VOLUMES TO 8-INCH TOP IN TREES
C 10.0 INCHES O.8.H. ANO LARGER.
C
C-----STATEMENTS FOR PROO ANO IF STATEMENT ARE SPECIES-SPECIFIC.
C
      IF(VOM .GT. 11.9) GO TO 30
      PROO = 0.87783 * VOM + 0.00660 * BA - 7.27957
      GO TO 40
   30 PROO = 5.10752 + 0.10712 * VOM + 0.00185 * BA - 36.20229 / VOM
   40 RETURN
      ENO
```

APPENDIX 1

Output of PONYLD

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 80., SUBSEQUENT - 80.

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	300	0					
30	288	57	6.0	27	630	300	0	662	62	560	0	0
40	286	83	7.3	36	1230	930	0					
50	284	107	8.3	45	1960	1680	1800					
50	172	78	9.1	46	1460	1320	1800	112	29	500	360	0
60	171	97	10.2	52	2070	1930	4800					
70	171	115	11.1	59	2840	2660	9200					
70	104	80	11.9	60	2030	1910	7500	67	35	810	750	1700
80	104	96	13.0	65	2700	2550	10500					
90	104	111	14.0	70	3400	3230	14400					
90	67	80	14.8	71	2480	2360	10900	37	31	920	870	3500
100	67	92	15.9	75	3050	2910	14400					
110	67	104	16.9	79	3630	3470	18000					
110	21	40	18.6	80	1410	1360	7400	46	64	2220	2110	10600
120	21	47	20.2	84	1740	1680	9700					
130	21	54	21.7	86	2080	2010	12200					
							TOTAL YIELDS			7090	6100	28000

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 80., SUBSEQUENT - 120.

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	300	0					
30	288	57	6.0	27	630	300	0	662	62	560	0	0
40	286	83	7.3	36	1230	930	0					
50	284	107	8.3	45	1960	1680	1400					
50	284	107	8.3	45	1960	1680	1400	0	0	0	0	0
60	281	130	9.2	51	2720	2460	4500					
70	276	148	9.9	58	3510	3240	8400					
70	200	120	10.5	58	2930	2740	8000	76	28	580	500	400
80	200	139	11.3	64	3800	3560	13500					
90	200	157	12.0	69	4670	4390	17100					
90	136	120	12.7	70	3600	3400	13800	64	37	1070	990	3300
100	136	135	13.5	74	4350	4120	17900					
110	136	150	14.2	77	5070	4820	22100					
110	44	61	15.9	79	2120	2020	9800	92	89	2950	2800	12300
120	44	71	17.2	82	2590	2480	12900					
130	44	81	18.4	85	3070	2950	16200					
							TOTAL YIELDS			8230	7240	31800

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 110., SUBSEQUENT - 100.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	310	0					
30	417	74	5.7	26	800	310	0	533	45	390	0	0
40	413	104	6.8	35	1500	1020	0					
50	406	131	7.7	44	2370	1900	1400					
50	239	94	8.5	45	1740	1520	1400	167	37	630	380	0
60	237	114	9.4	51	2410	2200	4200					
70	235	133	10.2	58	3220	2990	8200					
70	154	100	10.9	59	2460	2300	7300	81	33	760	690	900
80	154	117	11.8	65	3230	3030	12400					
90	154	133	12.6	69	4000	3780	15300					
90	104	100	13.3	70	3050	2890	12200	50	33	950	890	3100
100	104	114	14.2	74	3710	3530	15900					
110	104	129	15.1	78	4430	4220	20200					
110	32	49	16.8	80	1730	1660	8400	72	80	2700	2560	11800
120	32	58	18.3	83	2150	2060	11200					
130	32	68	19.7	86	2580	2490	14200					
						TOTAL YIELDS				8010	7010	29100

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 80., SUBSEQUENT - 80.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	300	0					
30	288	57	6.0	27	630	300	0	662	62	560	0	0
40	286	83	7.3	36	1230	930	0					
50	284	107	8.3	45	1960	1680	1800					
50	172	78	9.1	46	1460	1320	1800	112	29	500	360	0
60	171	97	10.2	52	2070	1930	4800					
70	171	115	11.1	59	2840	2660	9200					
70	104	80	11.9	60	2030	1910	7500	67	35	810	750	1700
80	104	96	13.0	65	2700	2550	10500					
90	104	111	14.0	70	3400	3230	14400					
90	41	53	15.4	72	1670	1590	7500	63	58	1730	1640	6900
100	41	63	16.8	76	2110	2020	10300					
110	41	73	18.1	79	2580	2470	13400					
110	12	26	19.8	81	930	890	5000	29	47	1650	1580	8400
120	12	31	21.7	84	1160	1120	6800					
130	12	36	23.5	87	1410	1360	8700					
						TOTAL YIELDS				6660	5690	25700

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 80., SUBSEQUENT - 120.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	300	0					
30	288	57	6.0	27	630	300	0	662	62	560	0	0
40	286	83	7.3	36	1230	930	0					
50	284	107	8.3	45	1960	1680	1400					
50	284	107	8.3	45	1960	1680	1400	0	0	0	0	0
60	281	130	9.2	51	2720	2460	4500					
70	276	148	9.9	58	3510	3240	8400					
70	200	120	10.5	58	2930	2740	8000	76	28	580	500	400
80	200	139	11.3	64	3800	3560	13500					
90	200	157	12.0	69	4670	4390	17100					
90	82	80	13.4	70	2460	2330	9800	118	77	2210	2060	7300
100	82	94	14.5	75	3070	2920	13300					
110	82	107	15.5	78	3700	3530	17100					
110	24	39	17.3	80	1390	1330	6900	58	68	2310	2200	10200
120	24	47	18.9	83	1730	1660	9200					
130	24	54	20.4	86	2090	2010	11700					
						TOTAL YIELDS				7750	6770	29200

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

YIELDS PER ACRE OF MANAGED, EVEN-AGED STANDS OF PONDEROSA PINE

SITE INDEX 70, 20-YEAR CUTTING CYCLE

THINNING LEVELS= INITIAL - 110., SUBSEQUENT - 100.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANTABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	950	119	4.8	25	1190	310	0					
30	417	74	5.7	26	800	310	0	533	45	390	0	0
40	413	104	6.8	35	1500	1020	0					
50	406	131	7.7	44	2370	1900	1400					
50	239	94	8.5	45	1740	1520	1400	167	37	630	380	0
60	237	114	9.4	51	2410	2200	4200					
70	235	133	10.2	58	3220	2990	8200					
70	154	100	10.9	59	2460	2300	7300	81	33	760	690	900
80	154	117	11.8	65	3230	3030	12400					
90	154	133	12.6	69	4000	3780	15300					
90	62	66	14.0	71	2050	1940	8500	92	67	1950	1840	6800
100	62	78	15.2	75	2570	2450	11600					
110	62	90	16.3	79	3120	2980	15000					
110	19	34	18.1	81	1210	1160	6200	43	56	1910	1820	8800
120	19	41	19.8	84	1510	1460	8300					
130	19	47	21.4	86	1830	1770	10600					
						TOTAL YIELDS				7470	6500	26200

MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO 8-INCH TOP.

APPENDIX 3

Listing and Output of Program PONCHK

```
      PROGRAM PONCHK
     1(INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=PUNCH)
C
C TO OBTAIN OATA FDR COMPUTING FUNCTIDNS USEO IN PDNYLO.
C
C OEFINITIDNS DF VARIABLES.
C
C      ADM(I) = AVERAGE OBH DF RESIDUAL STAND I.
C      AGE = AVERAGE AGE DF MAIN STAND TREES ON PLOT.
C      AHT(I) = AVERAGE HEIGHT OF RESIDUAL STANO I.
C      AREA = AREA OF PLDT.
C      BAS(I) = BASAL AREA OF RESIDUAL STAND I.
C      BDFC(I) = M BO. FT. REMOVED TD GET RESERVE STANO I, FROM TREE VDLS.
C      BFO(I) = M BD. FT. OF STAND I AS SUM OF TREE VOLUMES.
C      BHT(I) = AVERAGE HEIGHT OF DDM. AND COOOM. TREES ON PLDT.
C      BIG(I) = NUMBER OF OOM. ANO CODDM. TREES PER ACRE.
C      CC = CROWN CLASS DF INDIVIOUAL TREE.
C      CFMC(I) = MERCH. CU. FT. REMDVED TO GET RESERVE STAND I, TREE VDLS.
C      CFO(I) = MERCH. CU. FT. OF STANO I AS SUM DF TREE VOLUMES.
C      CRN(I) = CRDWN CLASS OF TREE I.
C      DBH = D.B.H. DF INDIVIDUAL TREE.
C      DEN(I) = NUMBER OF TREES IN RESIDUAL STAND I.
C      DIAM(I) = D.B.H. OF TREE I.
C      FCBF(I) = BD. FT. PER TOTAL CU. FT.
C      FCCM(I) = MERCH. CU. FT. PER TDTAL CU. FT.
C      GRPS(I) = NUMBER DF TREES IN GRDUP I.
C      HGT(I) = TDTAL HEIGHT OF TREE I.
C      HT = HEIGHT DF INDIVIDUAL TREE.
C      IRNO(I) = ARRAY OF PSEUOORANOOM NUMBERS.
C      KCINB(I) = CUBIC FEET PER M BO. FT., TREES REMOVEO ONLY.
C      NPLT = PLOT NUMBER.
C      NTIM = PAST OR PRESENT CDNOITIDN OF PLDT.
C      NWHN = COOEO RECORO OF WHETHER PLDT HAS BEEN THINNEO PREVIOUSLY.
C      PRET(I) = PCT. OF DRIGINAL TREES IN RESERVE STANO I.
C      RNCN(I) = CROWN CLASSES OF STANO TREES, IN RANOOM DROER.
C      RNOTR(I) = D.B.H. OF STANO TREES, IN RANDOM OROER.
C      RNHT(I) = HEIGHTS OF STANO TREES, IN RANOOM OROER.
C      SUBC(I) = MERCH. CU. FT. DF SUBSAWLOG TREES REMDVEO TO GET STANO
C           I, AS SUM OF INOIVIOUAL TREE VOLUMES.
C      SUBMF(I) = MERCH. CU. FT. SUBSAWLOG TREES IN STANO I AS A SUM OF
C           INOIVIOUAL TREE VOLUMES.
C      TOCC(I) = TOTAL CU. FT. REMOVEO TO GET RESERVE STANO I, TREE VOLS.
C      TOTO(I) = TOTAL CU. FT. OF STANO I AS SUM OF TREE VOLUMES.
C
      OIMENSION PRET(9),GRPS(9),TDCC(9),SUBMF(9),SUBC(9),CFO(9),CFMC(9),
     1BOFC(9),BFO(9),TOTO(9),OEN(9),BAS(9),AHT(9),AOM(9),BIG(9),BHT(9),F
     2CCM(9),FCBF(9),KPRET(9),KAOM(9),KBAS(9),KBHT(9),KAHT(9),KTOTO(9),K
     3FCCM(9),KFCBF(9),KOEN(9),OIAM(1DOO),HGT(IDOO),CRN(IOOO),IRNO(IOOO)
     4,RNOTR(1DOD),RNHT(1000),RNCN(IOOO),KCINB(9)
C
C INITIALIZE BATCH VARIABLES.
C
      GRPS(I) = IO.0
      GRPS(2) = 6.0
      GRPS(3) = 5.0
      GRPS(4) = 4.0
      GRPS(5) = 3.0
      GRPS(6) = 2.0
      GRPS(7) = 3.0
      GRPS(B) = 4.D
      GRPS(9) = I.0
C
C INITIALIZE PLOT VARIABLES.
C
    I TERM = 2I.0
      AREA = 0.0
      00 3 I=1,1D00
      CRN(I) = 0.0
      OIAM(I) = 0.0
      HGT(I) = 0.0
      IRNO(I) = 0
      RNOTR(I) = 0.0
      RNCN(I) = 0.0
      RNHT(I) = D.0
    3 CONTINUE
      00 6 I=1,9
      ADM(I) = D.0
      AHT(I) = 0.0
      BAS(I) = 0.0
      BOFC(I) = 0.0
      BFO(I) = 0.0
      BHT(I) = 0.D
      BIG(I) = 0.0
      CFMC(I) = 0.0
      CFO(I) = 0.0
      OEN(I) = 0.0
      FCBF(I) = 0.0
      FCCM(I) = 0.0
      KAOM(I) = 0
      KAHT(I) = 0
      KBAS(I) = 0
      KBHT(I) = 0
      KCINB(I) = D
      KOEN(I) = 0
      KFCBF(I) = 0
      KFCCM(I) = 0
      KPRET(I) = 0
      KTOTO(I) = 0
      PRET(I) = 0.0
      SUBC(I) = 0.0
      SUBMF(I) = 0.0
      TOCC(I) = 0.0
      TOTO(I) = D.0
    6 CONTINUE
      REAO (5,IO) NPLT,NTIM,NWHN,AREA,AGE
   1D FORMAT (I3,2I2,F5.3,F4.0)

      IF(NPLT .EQ. BBB) GO TO 400
C
C EXPANO STANO TABLE TO ACRE BASIS.
C REAO IN TREE VALUES IN OROER OF OBH, SMALLEST FIRST.
C
      ACRE = I.0 / AREA
      KA = I
      DD 17 L=I,1DDD
      READ (5,I5) DBH,HT,CC
   I5 FDRMAT (F3.I,2F3.D)
      IF(DBH .EQ. 99.9) GO TO 1B
      AA = L
      MULT = ACRE * AA
      IF(MULT .LE. D) MULT = 1
      DD I6 I=KA,MULT
      DIAM(I) = DBH
      HGT(I) = HT
      CRN(I) = CC
   16 CONTINUE
      KA = MULT + 1
   I7 CDNTINUE
   IB TREES = MULT
C
C COMPUTE VALUES DF STAND PRIDR TD THINNING.
C
      PRET(9) = IDD.D
      DD 34 I=I,MULT
      SQFT = D.0
      TREBF = D.D
      TREMCF = D.D
      TRETOT = D.0
      SQFT = 0.DD54542 * DIAM(I) * DIAM(I)
      D2H = DIAM(I) * OIAM(I) * HGT(I)
C
C-----IF STATEMENT ANO STATEMENTS FDR TRETOT ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6DDD.0) GO TO 20
      TRETDT = 0.002213 * 02H + D.0302B8
      GO TO 22
   2D TRETOT = D.002474 * 02H - 1.557I03
C
C-----CHANGE 6.0 IF OTHER MINIMUM O.B.H. WANTEO FOR MERCH. CU. FT.
C
   22 IF(OIAM(I) .LT. 6.0) GO TD 30
C
C-----IF STATEMENT ANO STATEMENTS FOR TREMCF ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6700.0) GO TO 24
      TREMCF = 0.D02297 * 02H - 1.032297
      GO TO 26
   24 TREMCF = 0.002407 * 02H - 2.257724
C
C-----CHANGE IO.0 IF OTHER MINIMUM O.B.H. WANTEO FOR BD. FT.
C
   26 IF(OIAM(I) .LT. 10.0) GO TO 30
C
C-----IF STATEMENT AND STATEMENTS FDR TREBF ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. I6000.0) GO TO 2B
      TREBF = (0.0I2331 * D2H - 34.I67I70) * 0.001
      GD TO 30
   2B TREBF = (0.01631B * 02H - 99.2I272D) * 0.001
C
C COMPUTE ACTUAL PLCT VALUES AS SUMS OF INOIVIOUAL TREE VALUES.
C
   3D AHT(9) = AHT(9) + HGT(I)
      BAS(9) = BAS(9) + SQFT
      BFO(9) = BFO(9) + TREBF
      CFO(9) = CFO(9) + TREMCF
      TOTO(9) = TDTO(9) + TRETOT
      OEN(9) = OEN(9) + 1.0
      IF(CRN(I) .GT. 2.0) GO TO 32
      BHT(9) = BHT(9) + HGT(I)
      BIG(9) = BIG(9) + I.0
C
C-----CHANGE I0.0 IF OTHER MINIMUM O.B.H. USEO FDR BO. FT.
C
   32 IF(OIAM(I) .GE. 10.0) GO TO 34
      SUBMF(9) = SUBMF(9) + TREMCF
   34 CDNTINUE
      ADM(9) = BAS(9) / (0.0054542 * OEN(9))
      IF(AOM(9) .LE. 0.0) GO TO 36
      ADM(9) = SQRT(ADM(9))
   36 IF(OEN(9) .LE. 0.0) GO TO 3B
      AHT(9) = AHT(9) / OEN(9)
   3B IF(BIG(9) .LE. D.0) GO TO 50
      BHT(9) = BHT(9) / BIG(9)
C
C COMPUTE VALUE OF MOOULD FOR GENERATOR SUITABLE FOR PLOT OENSITY.
C
   50 00 55 I=1,I2
      TEM = I
      TWOPR = 2.0 ** TEM
      IF(TWOPR .GE. TREES) GO TO 60
   55 CONTINUE
   6D NTWO = TWOPR + 0.5
C
C GENERATE PSEUODRANOOM NUMBERS.
C
      00 B5 I=1,MULT
   B0 NDIV = (I7.0 * TERM + 3.0) / TWOPR
      NTERM = TERM
      NTERM = (17 * NTERM + 3) - NTWO * NOIV
      TERM = NTERM
      IF(NTERM .LE. 0) GO TO B0
      IF(NTERM .GT. MULT) GO TO B0


   B5 IRND(I) = NTERM
C
C REARRANGE TREES AT RANOOM.
C
      00 90 I=I,MULT
      NBR = IRNO(I)
      RNOTR(NBR) = OIAM(I)
      RNHT(NBR) = HGT(I)
      RNCN(NBR) = CRN(I)
   90 CONTINUE
C
C APPLY OESIGNATEO THINNING LEVELS, ONE AT A TIME.
C RETAIN ONE TREE FROM EACH GROUP.
C
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      00 150 M=1,6
      NOGP = TREES / GRPS(M)
      ANOGP = NOGP
      TEM = ANOGP * GRPS(M)
      IF(TEM .EO. TREES) GO TO 92
      NOGP = NOGP + 1
      ANOGP = ANOGP + 1.0
C
C SELECT LARGEST TREE IN EACH GROUP.
C
   92 LX = 1
      IGP = GRPS(M)
      MX = IGP
      00 125 IJ=1,NOGP
      00 94 IL=1,MULT
      JK = MULT - IL + 1
      00 94 NK=LX,MX
      NBR = NK
      IF(RNOTR(NBR) .EO. OIAM(JK)) GO TO 98
   94 CONTINUE
C
C COMPUTE BASAL AREA ANO VOLUME OF EACH SELECTEO TREE.
C
   98 SOFT = 0.0
      TREBF = 0.0
      TREMCF = 0.0
      TRETOT = 0.0
      SOFT = 0.0054542 * RNOTR(NBR) * RNOTR(NBR)
      02H = RNOTR(NBR) * RNOTR(NBR) * RNHT(NBR)
C
C-----IF STATEMENT ANO STATEMENTS FOR TRETOT ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6000.0) GO TO 100
      TRETOT = 0.002213 * 02H + 0.030288
      GO TO 102
  100 TRETOT = 0.002474 * 02H - 1.557103
C
C-----CHANGE 6.0 IF OTHER MINIMUM O.B.H. USEO FOR MERCH. CU. FT.
C
  102 IF(RNOTR(NBR) .LT. 6.0) GO TO 110
C
C-----IF STATEMENT ANO STATEMENTS FOR TREMCF ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6700.0) GO TO 104
      TREMCF = 0.002297 * 02H - 1.032297
      GO TO 106
  104 TREMCF = 0.002407 * 02H - 2.257724
C
C-----CHANGE 10.0 IF OTHER MINIMUM O.B.H. USEO FOR BO. FT.
C
  106 IF(RNOTR(NBR) .LT. 10.0) GO TO 110
C
C-----IF STATEMENT ANO STATEMENTS FOR TREBF ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 16000.0) GO TO 108
      TREBF = (0.012331 * 02H - 34.167170) * 0.001
      GO TO 110
  108 TREBF = (0.016318 * 02H - 99.212720) * 0.001
  110 AHT(M) = AHT(M) + RNHT(NBR)
      IF(RNCN(NBR) .GT. 2.0) GO TO 115
      BHT(M) = BHT(M) + RNHT(NBR)
      BIG(M) = BIG(M) + 1.0
  115 BAS(M) = BAS(M) + SOFT
      TOTO(M) = TOTO(M) + TRETOT
      CFO(M) = CFO(M) + TREMCF
      BFO(M) = BFO(M) + TREBF
      OEN(M) = OEN(M) + 1.0
C
C-----CHANGE 10.0 IF OTHER MINIMUM O.B.H. USEO FOR BO. FT.
C
      IF(RNOTR(NBR) .GE. 10.0) GO TO 120
      SUBMF(M) = SUBMF(M) + TREMCF
  120 LX = MX + 1
  125 MX = MX + IGP
C
C COMPUTE ACTUAL PLOT VALUES.
C
      AOM(M) = BAS(M) / (0.0054542 * OEN(M))
      IF(AOM(M) .LE. 0.0) GO TO 130
      AOM(M) = SORT(AOM(M))
  130 IF(OEN(M) .LE. 0.0) GO TO 135
      AHT(M) = AHT(M) / OEN(M)
  135 IF(BIG(M) .LE. 0.0) GO TO 140
      BHT(M) = BHT(M) / BIG(M)
  140 PRET(M) = (OEN(M) / OEN(9)) * 100.0
C
C COMPUTE VALUES FOR PART OF STANO TO BE REMOVEO.
C
      SUBC(M) = SUBMF(9) - SUBMF(M)
      CFMC(M) = CFO(9) - CFO(M)
      BOFC(M) = BFO(9) - BFO(M)
      TOCC(M) = TOTO(9) - TOTO(M)


  150 CONTINUE
C
C APPLY OESIGNATEO THINNING LEVELS, ONE AT A TIME.
C REMOVE ONE TREE FROM EACH GROUP.
C
      DO 200 M=7,8
      NOGP = TREES / GRPS(M)
      ANOGP = NOGP
      TEM = ANOGP * GRPS(M)
      IF(TEM .EO. TREES) GO TO 152
      NOGP = NOGP + 1
      ANOGP = ANOGP + 1.0
C
C SELECT SMALLEST TREE IN EACH GROUP.
C
  152 LX = 1
      IGP = GRPS(M)
      MX = IGP
      00 175 IJ=1,NOGP
      00 154 IL=1,MULT
      00 154 NK=LX,MX
      NBR = NK
      IF(RNOTR(NBR) .EO. OIAM(IL)) GO TO 158
  154 CONTINUE
C
C COMPUTE BASAL AREA ANO VOLUME OF EACH SELECTEO TREE.
C
  158 SOFT = 0.0
      TREBF = 0.0
      TREMCF = 0.0
      TRETOT = 0.0
      SOFT = 0.0054542 * RNOTR(NBR) * RNOTR(NBR)
      02H = RNOTR(NBR) * RNOTR(NBR) * RNHT(NBR)
C
C-----IF STATEMENT ANO STATEMENTS FOR TRETOT ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 6000.0) GO TO 160
      TRETOT = 0.002213 * 02H + 0.030288
      GO TO 162
  160 TRETOT = 0.002474 * 02M - 1.557103
C
C-----CHANGE 6.0 IF OTHER MINIMUM O.B.H. USEO FOR MERCH. CU. FT.
C
  162 IF(RNOTR(NBR) .LT. 6.0) GO TO 170
C
C-----IF STATEMENT ANO STATEMENTS FOR TREMCF ARE SPECIES-SPECIFIC.
C
      IF(02M .GT. 6700.0) GO TO 164
      TREMCF = 0.002297 * 02M - 1.032297
      GO TO 166
  164 TREMCF = 0.002407 * 02H - 2.257724
C
C-----CHANGE 10.0 IF OTHER MINIMUM O.B.H. USEO FOR BO. FT.
C
  166 IF(RNOTR(NBR) .LT. 10.0) GO TO 170
C
C-----IF STATEMENT ANO STATEMENTS FOR TREBF ARE SPECIES-SPECIFIC.
C
      IF(02H .GT. 16000.0) GO TO 168
      TREBF = (0.012331 * 02H - 34.167170) * 0.001
      GO TO 170
  168 TREBF = (0.016318 * 02H - 99.212720) * 0.001
  170 AHT(M) = AHT(M) + RNHT(NBR)
      IF(RNCN(NBR) .GT. 2.0) GO TO 172
      BHT(M) = BHT(M) + RNHT(NBR)
      BIG(M) = BIG(M) + 1.0
  172 BAS(M) = BAS(M) + SOFT
      TOTO(M) = TOTO(M) + TRETOT
      CFO(M) = CFO(M) + TREMCF
      BFO(M) = BFO(M) + TREBF
      OEN(M) = OEN(M) + 1.0
C
C-----CHANGE 10.0 IF OTHER MINIMUM O.B.H. USEO FOR BO. FT.
C
      IF(RNOTR(NBR) .GE. 10.0) GO TO 174
      SUBMF(M) = SUBMF(M) + TREMCF
  174 LX = MX + 1
  175 MX = MX + IGP
      AHT(M) = AHT(9) * OEN(9) - AHT(M)
      BHT(M) = BHT(9) * BIG(9) - BHT(M)
      BIG(M) = BIG(9) - BIG(M)
      BAS(M) = BAS(9) - BAS(M)
      TOTO(M) = TOTO(9) - TOTO(M)
      CFO(M) = CFO(9) - CFO(M)
      BFO(M) = BFO(9) - BFO(M)
      OEN(M) = OEN(9) - OEN(M)
      SUBMF(M) = SUBMF(9) - SUBMF(M)
C
C COMPUTE ACTUAL PLOT VALUES.
C
      AOM(M) = BAS(M) / (0.0054542 * OEN(M))
      IF(AOM(M) .LE. 0.0) GO TO 180
      AOM(M) = SORT(AOM(M))
  180 IF(OEN(M) .LE. 0.0) GO TO 185
      AHT(M) = AHT(M) / OEN(M)
  185 IF(BIG(M) .LE. 0.0) GO TO 190
      BHT(M) = BHT(M) / BIG(M)
  190 PRET(M) = (OEN(M) / OEN(9)) * 100.0
C
C COMPUTE VALUES FOR PART OF STANO TO BE REMOVEO.
C
      SUBC(M) = SUBMF(9) - SUBMF(M)
      CFMC(M) = CFO(9) - CFO(M)
      BOFC(M) = BFO(9) - BFO(M)
      TOCC(M) = TOTO(9) - TOTO(M)
  200 CONTINUE


C
C COMPUTF VOLUME CONVERSION FACTORS FOR EACH PLOT.
C
      00 260 I=1,9
      IF(BOFC(I) .EO. 0.0) GO TO 255
      KCINB(I) = ((CFMC(I) - SUBC(I)) / BOFC(I)) * 10000.0
  255 IF(TOTO(I) .EO. 0.0) GO TO 260
      FCCM(I) = CFO(I) / TOTO(I)
      FCBF(I) = (BFO(I) * 1000.0) / TOTO(I)
  260 CONTINUE
C
C SET NUMBER OF OECIMAL PLACES TO BE RETAINEO FOR PUNCHING.
C
      00 270 I=1,9
      KAOM(I) = AOM(I) * 100.0 + 0.5
      KAHT(I) = AHT(I) * 100.0 + 0.5
      KBAS(I) = BAS(I) * 100.0 + 0.5
      KBHT(I) = BHT(I) * 100.0 + 0.5
      KOEN(I) = OEN(I)
      KFCBF(I) = FCBF(I) * 1000.0 + 0.5
      KFCCM(I) = FCCM(I) * 1000.0 + 0.5
      KPRET(I) = PRET(I) * 1000.0 + 0.5
      KTOTO(I) = TOTO(I) * 100.0 + 0.5
  270 CONTINUE
C
C WRITE RESULTS, ONE PAGE PER PLOT.
C
      WRITE (6,300)
  300 FORMAT (1H1,/,44X,40HVOLUME ANALYSIS OF PONOEROSA PINE STANOS)
      WRITE (6,302) NPLT,NT1M,NWHN
  302 FORMAT (1HO,9X,11HPLOT NUMBER,I4,1X,1H-,I2,1X,1H-,I2)
      WRITE (6,304) PRET
  304 FORMAT (1HO,/,1X,19HPCT. TREES RETAINEO,4X,9F10.2)
      WRITE (6,306) OEN
  306 FORMAT (1HO,12HNO. OF TREES,11X,9F10.0)
      WRITE (6,308) BIG
  308 FORMAT (1HO,19HNO. OOM. ANO COOOM.,4X,9F10.0)
      WRITE (6,310) AOM
  310 FORMAT (1HO,14HAVERAGE O.B.H.,9X,9F10.2)
      WRITE (6,312) AHT
  312 FORMAT (1HO,14HAVERAGE HEIGHT,9X,9F10.2)
      WRITE (6,314) BHT
  314 FORMAT (1HO,18HAVE. HT. O. ANO C.,5X,9F10.2)
      WRITE (6,316) BAS
  316 FORMAT (1HO,10HBASAL AREA,13X,9F10.2)
      WRITE (6,320)
  320 FORMAT (1HO,35HACTUAL VOLUMES, FROM TREE VOLUMES -)
      WRITE (6,322) TOTO
  322 FORMAT (1HO,5X,13HTOTAL CU. FT.,5X,9F10.2)
      WRITE (6,324) CFO
  324 FORMAT (1HO,5X,14HMERCH. CU. FT.,4X,9F10.2)
      WRITE (6,326) BFO
  326 FORMAT (1HO,5X,9HM BO. FT.,9X,9F10.2)
```

```
      WRITE (6,328) SU8MF
  328 FORMAT (1MO,5X,18MCU. FT., SU8SAWLOG,9F10.2)
      WRITE (6,330)
  330 FORMAT (1HO,29MCONVERSION OF TOTAL CU. FT. -)
      WRITE (6,332) FCCM
  332 FORMAT (1MO,5X,16MTO MERCM CU. FT.,2X,9F10.3)
      WRITE (6,334) FC8F
  334 FORMAT (1HO,5X,IOMTO 80. FT.,8X,9FIO.3)
      WRITE (6,345)
  345 FORMAT (1MO,36HVOLUMES REMOVED, FROM TREE VOLUMES -)
      WRITE (6,322) TOCC
      WRITE (6,324) CFMC
      WRITE (6,326) 8OFC
      WRITE (6,328) SU8C
C
C PUNCM RESULTS FOR INPUT TO REGRESSION ANALYSIS.
C
      OO 365 I=1,9
      WRITE (7,360) NPLT,NTIM,NWMN,KPRET(I),KAOM(I),K8AS(I),K8MT(I),KAHT
     1(I),KOEN(I),KTOTO(1),KCIN8(I),K8MT(9)
  360 FORMAT (I3,2I2,17,I5,3I6,15,2I7,I6)
  365 CONTINUE
      OO 375 I=I,9
      WRITE (7,370) NPLT,NTIM,NWHN,KPRET(1),KAOM(9),KOEN(1),KAOM(I)
  370 FORMAT (I3,2I2,I7,3I5)
  375 CONTINUE
      OO 385 I=1,9
      WRITE (7,380) NPLT,NTIM,NWHN,KAOM(I),K8AS(I),KFCCM(I),KFC8F(1)
  380 FORMAT (I3,2I2,I5,3I6)
  385 CONTINUE
      GO TO 1
  400 CALL EXIT
      ENO
```

VOLUME ANALYSIS OF PONOEROSA PINE STANOS

PLOT NUM8ER 62 - 2 - 2

PCT. TREES RETAINEO	10.00	17.14	20.00	25.71	34.29	50.00	65.71	74.29	100.00
NO. OF TREES	7.	12.	14.	18.	24.	35.	46.	52.	70.
NO. OOM. ANO COOOM.	7.	12.	14.	18.	24.	35.	46.	52.	66.
AVERAGE O.8.H.	19.86	19.17	19.06	18.90	18.29	17.85	17.50	17.56	16.67
AVERAGE HEIGHT	86.86	85.17	85.07	85.39	83.87	83.46	83.02	83.02	82.10
AVE. HT. O. ANO C.	86.86	85.17	85.07	85.39	83.87	83.46	83.02	83.02	82.29
8ASAL AREA	15.06	24.04	27.73	35.06	43.81	60.84	76.85	87.45	106.09
ACTUAL VOLUMES, FROM TREE VOLUMES -									
TOTAL CU. FT.	584.07	913.54	1051.99	1333.21	1638.01	2261.05	2835.88	3227.72	3873.63
MERCH. CU. FT.	563.06	879.89	1013.10	1283.74	1575.82	2173.82	2724.91	3101.68	3716.73
M 8O. FT.	3.23	4.96	5.69	7.19	8.67	11.80	14.62	16.66	19.49
CU. FT., SU8SAWLOG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CONVERSION OF TOTAL CU. FT. -									
TO MERCH CU. FT.	.964	.963	.963	.963	.962	.961	.961	.961	.959
TO 8O. FT.	5.530	5.427	5.412	5.395	5.293	5.219	5.156	5.163	5.032
VOLUMES REMOVEO, FROM TREE VOLUMES -									
TOTAL CU. FT.	3289.56	2960.09	2821.64	2540.42	2235.62	1612.58	1037.75	645.91	0.00
MERCH. CU. FT.	3153.67	2836.84	2703.63	2432.99	2140.91	1542.91	991.82	615.05	0.00
M 8O. FT.	16.26	14.54	13.80	12.30	10.82	7.69	4.87	2.83	0.00
CU. FT., SU8SAWLOG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Myers, Clifford A.
1971. Field and computer procedures for managed-stand yield tables. USDA Forest Service Research Paper RM-79, 24 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Sets of yield tables that show probable results of various management alternatives can be valuable tools for decisionmaking, especially when they can be made available quickly and at relatively low cost. Such tables can be obtained with data from temporary plots and the computer programs presented.

Key words: Stand yield tables, timber management, simulation, managed stands, _Pinus ponderosa_.

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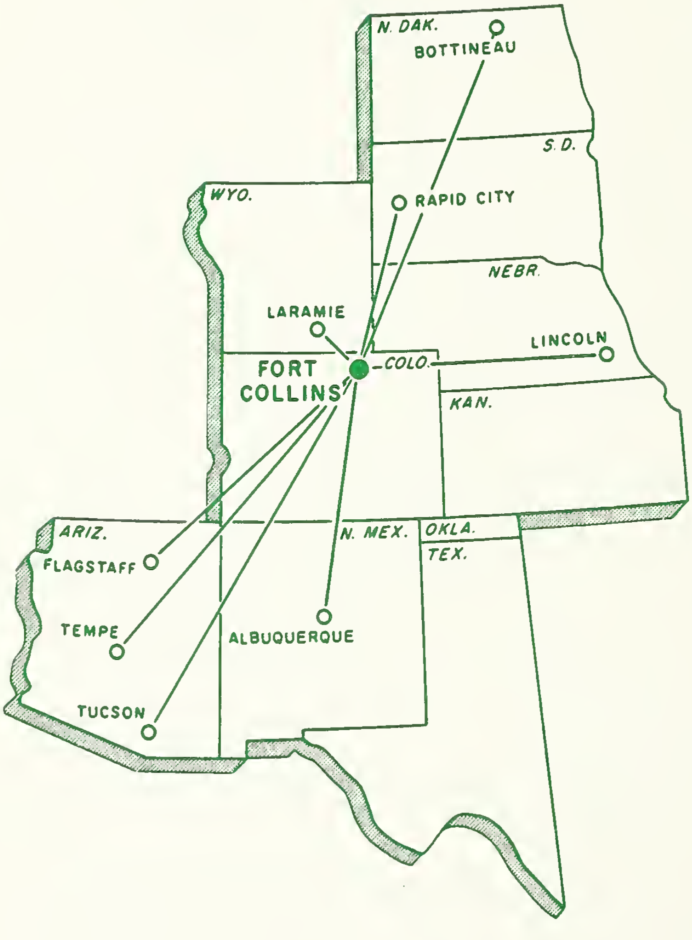
N. DAK.
BOTTINEAU
S. D.
WYO.
RAPID CITY
NEBR.
LARAMIE
LINCOLN
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COLO.
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